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# Noise Levels and Data Analyses for Small Prop-Driven Aircraft



By:
J. Steven Newman
Tyrone L. Bland
Sharon A. Daboin

U.S. Department of Transportation
**Federal Aviation Administration**

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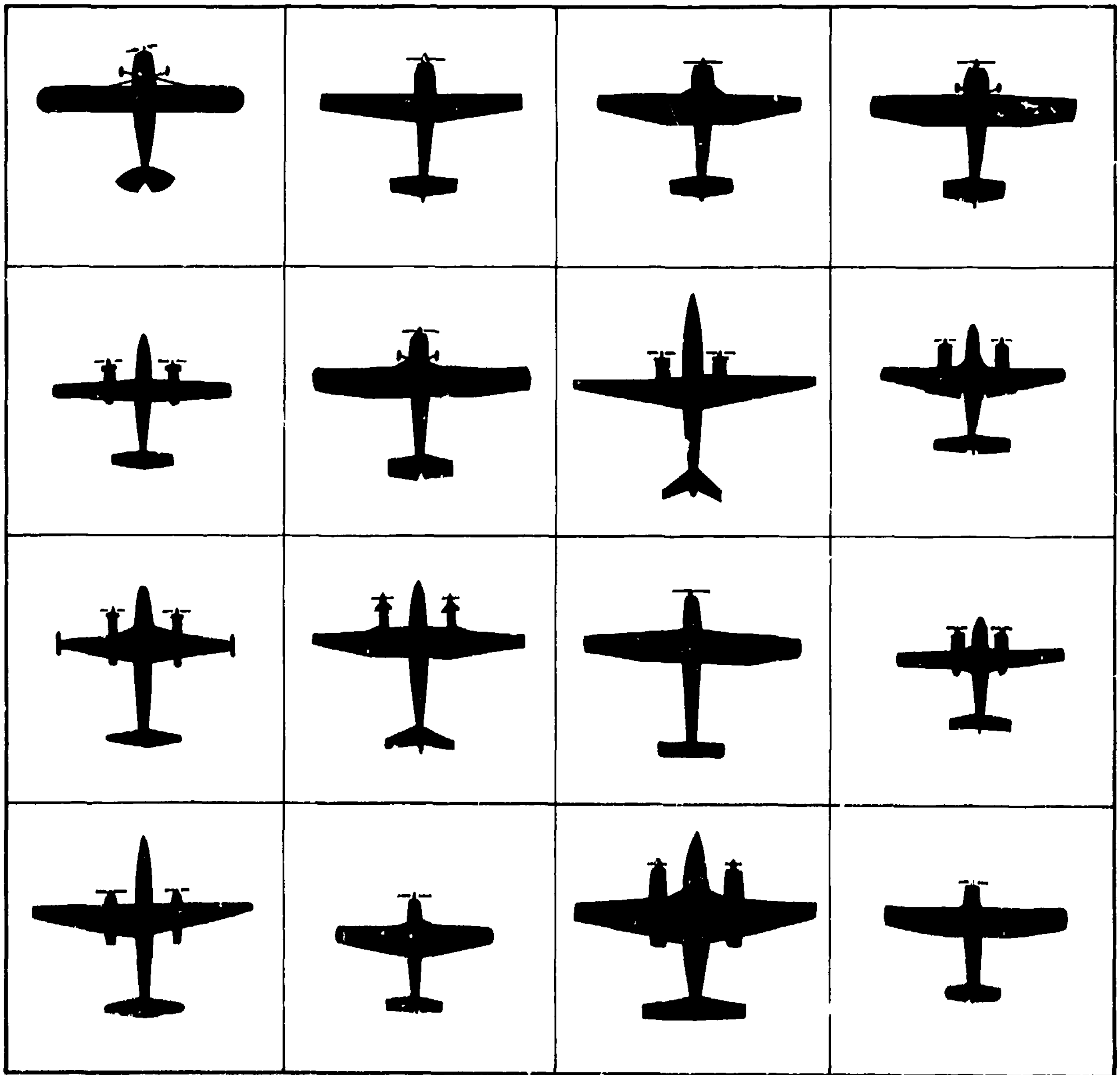

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16. Abstract

During the Summer and Fall of 1982, the FAA Office of Environment and Energy, Noise Abatement Division, conducted a noise measurement program to evaluate proposed revisions of International and U.S. noise certification standards for light-weight propeller-driven aircraft. Tests were conducted using both single- and twin-engine propeller-driven light aircraft. Normally aspirated, turbo-charged, and turboprop engines were included, as were both fixed and variable pitch propellers. Takeoff noise measurements were made for eighteen aircraft. Additional measurements for nine of these aircraft (during level flight) provided sufficient data to examine the relationship of noise level versus helical tip Mach Number and engine power setting. This report presents noise measurements, aircraft position data, meteorological data, and cockpit instrument readings acquired during the test. Data analyses include: 1) corrections to proposed noise certification reference conditions, 2) development of Mach Number and Power Correction functions, 3) empirical examination of sound propagation, 4) regression of noise level versus weight (and the logarithm of weight) and 5) correlation of acoustical intensity (AL) and acoustical dose (SEL) noise metrics. While this report concludes that a takeoff noise certification procedure is feasible and will provide consistent results for a given aircraft, it remains uncertain whether or not equal stringency (or even comparable stringency) can be achieved between the existing certification procedure and the proposed takeoff procedure.

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## Errata

In a recently conducted(July 1983) retest of the identical Cessna 210 Centurion discussed in this report it was determined that a tachometer error existed. While the tachometer read 2700 the actual propeller RPM was 2882.

Accordingly, it is assumed that the tachometer error existed during the 1982 test. Therefore, any reference in the main body of this document to the C-210 or any presentation of C-210 data should be noted as reflecting a propeller speed approximately 182 RPM greater than the stated value. The results of the 1983 retest are presented in Appendix E.

## Addenda

Appendix E of this document provides a summary of the 1983 Cessna 210, "retest" measurement program designed to obtain additional data on the relationship between level flyover and takeoff noise levels.

## Acknowledgments

The Authors wish to express appreciation to all of those who participated in the measurement program and whose cooperation was instrumental in making the program a success. Thanks to Mr. Neal Phillips for his assistance in preparing this document and to Ms. Loretta Harrison for her typing support.

Our special thanks are extended to the following participating organizations:

- General Aviation Manufacturer's Association
- Aircraft Owners and Pilots Association
- Beech Aircraft Company
- Cessna Aircraft Company
- Piper Aircraft Company

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## GLOSSARY

| | | |
|---|---|---|
| ABS | = | Atmospheric absorption correction applied to each 1/3 octave band of the ALM |
| AGL | = | Above Ground Level |
| AL | = | A-Weighted Sound Level, expressed in decibels (See $L_A$) |
| ALM | = | Maximum A-weighted Sound Level, expressed in decibels (see $L_{AM}$) |
| $AL_{cx}$ | = | Maximum A-weighted Sound Level Corrected using complex procedure |
| $AL_{cs}$ | = | Maximum A-weighted Level corrected using simplified procedures |
| $AL_{AM}$ | = | As measured maximum A-weighted Level |
| ALT | = | Aircraft altitude above the microphone location |
| $ALT_R$ | = | Reference Altitude - reference height of aircraft |
| $ALT_T$ | = | Test Altitude - actual height of aircraft directly over noise measurement site |
| ATM | = | Standard day atmospheric correction |
| BRC | = | Best Rate of Climb |
| c | = | Speed of Sound |
| cm | = | When used as subscript cm refers to distance and Mach number corrected levels |
| CPA | = | Closest Point of Approach |
| CR | = | Correction Ratio |
| dB | = | Decibel |
| dBA | = | A-Weighted Sound Level expressed in units of decibels (see $A_L$) |

df = Degree of freedom

d = Distance

$d_{50}$ = Distance from brake release to clear a 50' (15.4m) obstacle

$\Delta$ = Delta, or Change in Value

$\Delta_1$ = Correction term obtained by correcting SPL values for atmospheric absorption and flight track deviations per FAR 36, Amendment 9, Appendix A, Section A36.11, Paragraph d

$\Delta_2$ = Correction term accounting for changes in event duration with deviations from the reference flight path

EPNL = Effective Perceived Noise Level (symbol is $L_{EPN}$)

EV = Event, test run number

FAA = Federal Aviation Administration

FAR = Federal Aviation Regulation

FAR-36 = Federal Aviation Regulation, Part 36

GA = General Aviation

GLR = Graphic Level Recorder

IAS = Indicated Airspeed

K(A) = Propagation constant describing the change in dBA with distance

K(DUR) = The constant used to correct SEL for distance and velocity duration effects in $\Delta 2$

K(S) = Propagation constant describing the change in SEL with distance

$K(M)_A$ = Mach Number correction constant for AL

$K(M)_S$ = Mach Number correction constant for SEL

$K(P)_A$ = Power correction constant for the AL

$K(P)_S$ = Power correction for SEL

Kts = Knots

$L_A$ = Symbol for A-Weighted Sound Level expressed in decibels (see AL)

$L_{Acx}$ = Symbol for Maximum A-weighted Sound Level corrected using complex procedure

$L_{AE}$ = Symbol for Sound Exposure Level expressed in decibels (see SEL)

$L_{AEcs}$ = Symbol for Sound Exposure Level corrected with simplified procedure

$L_{AEcx}$ = Symbol for Sound Exposure Level corrected with complex procedures

$L_{AEAM}$ = Symbol for As measured Sound Exposure Level

$L_{AM}$ = Symbol for maximum A-weighted Sound Level expressed in decibels (See ALM)

$L_{AM(am)}$ Symbol for as measured Maximum A-weighted Sound Level expressed in decibels

Leq = Symbol for Equivalent Sound Level

LFO = Level Flyover operational mode

$M_H$ = Helical Tip Mach number

$M_H(T)$ = Test helical tip Mach number

$M_H(R)$ = Reference helical tip Mach number

MTOGW = Maximum Takeoff Gross Weight

N = Sample Size

$P_R$ = Reference engine power

$P_T$ = Test engine power

Q = Time history "shape factor"

RH = Relative Humidity in percent

RPM = Revolutions per minute

| | | |
|---|---|---|
| SD | = | Standard Deviation |
| SEL | = | Sound Exposure Level expressed in decibels. The integration of the AL time history, normalized to 1 second (symbol is $L_{AE}$) |
| $SEL_{AM}$ | = | As measured Sound Exposure Level |
| $SEL_{CX}$ | = | Sound Exposure Level corrected with complex procedures |
| $SEL_{CS}$ | = | Sound Exposure Level corrected with simplified procedure |
| $SEL_{FC}$ | = | Fully corrected SEL value |
| SPH | = | Correction added to the 1/3 octave band value to adjust for spherical spreading |
| SPL | = | Sound Pressure Level |
| SR | = | Distance from the noise source to receiver |
| T | = | Ten-dB-down duration time |
| T/O | = | Takeoff |
| v | = | Velocity |
| Vy | = | Velocity for best rate of climb |
| $V_R$ | = | Rotational Velocity |
| $V_T$ | = | Translational Velocity |
| Vg | = | Ground speed |
| $V_{IAS}$ | = | Indicated Air Speed |
| $\alpha_i$ | = | Atmospheric absorption coefficient for the i-th 1/3 octave Sound Pressure Level |
| $\alpha^\circ_i$ | = | SAE ARP-866A absorption coefficient for the i-th 1/3 octave band for the reference conditions of 59°F (15°C) and 70% RH |

## Executive Summary of Findings

1. For the aircraft, groundspeeds, and altitudes tested, a strong correlation is observed between SEL and ALM. ALM and SEL are linearly related, with a coefficient of determination ($R^2$) of 0.965.

In a noise certification scheme the use of ALM is substantially simpler and more direct than SEL because:

a. there is no need for tracking information, which is required to measure ground speed;

b. measurement instrumentation is far less sophisticated;

c. corrections for off-reference test conditions are simpler and less time-consuming; and

d. fewer corrections are required.

Based on these observations, it is reasonable to consider use of ALM as the noise evaluation measure for a takeoff noise certification procedure.

2. For ratios of test altitude to reference altitude from 1.2 to 0.8, a comparisons of two methods (i.e., a "simplified" and a "complex) for correcting nonreference altitudes and nonstandard atmospheric absorption resulted in an average difference of only 0.2 dB between the two methods. It is concluded that the less complex correction method is quite acceptable. Using the "simplified" procedure, measured noise levels (ALM) may be corrected for altitude by algebraically adding an increment equal to:

$$\text{Delta-1} = 22 \log (ALT_T/ALT_R) \text{ dB.}$$

3. The results of the helical tip Mach Number ($M_H$) correlation study suggest that no single function should be universally applied. Test results show that functions for the aircraft tested lie between 20 and 150 times log $(M_{H(R)}/M_{H(T)})$. However, the method of application as a correction function minimizes the net difference in correction value, since, in most cases, the $M_{H(R)}/M_{H(T)}$ was very close to 1.0. On the average there was less than a 1 percent difference over the range of coefficients, primarily due to warmer than standard day temperatures.

4. Test results reveal a range of values for the power correction constant $K(P)_A$ between 2 and 30, with an average $K(P)_A = 17$. The relationship $\Delta = K(P)_A \log (P_{(R)}/P_{(T)})$ db is considered a reasonable correction factor for estimating change in noise level with engine power.

5. Pilots participating in the FAA tests flew within 5 kts. of the reference airspeed.

6. In most cases (11 of 18) the altitude correction ratios $(ALT_T/ALT_R)$ for the test aircraft lie within the limits of 0.7 and 1.4. In a number of cases an unusually high correction ratio is observed, generally associated with winds aloft and/or light weight.

7. Linear and logarithmic regression analyses of noise level versus maximum gross takeoff weight failed to reveal any significant trends for the general population of aircraft tested. Subsequent analyses using sub-ground populations made no significant improvement.

8. Pilots participating in the FAA test reported difficulty in maintaing the reference heading due to their inability to see the ground while in the climbout flight regime. Typically each pilot would make practice flights

until receiving radio confirmation from ground observers verifying the proper flight track. The pilot would then fly that compass heading for subsequent takeoff events. After having found the right compass heading, pilots typically deviated no more than $\pm 10$ degrees from the zenith over the microphone location.

1.0 <u>Introduction</u> - During the Summer and Fall of 1982, the Federal Aviation Administration's Office of Environment and Energy, Noise Abatement Division, conducted an extensive propeller-driven aircraft noise measurement program at Dulles International Airport. This program was intended to obtain noise measurement data necessary for analysis of the proposed revision of ICAO Annex 16/FAA FAR Part 36, noise standards for certification of small (less than 12,500 lbs) propeller-driven aircraft.

ICAO and FAA noise standards prescribe procedures for noise certification of small propeller-driven airplanes. The standards require measurement of noise levels associated with 1000 ft (300m) level flyover at not less than the highest power in the normal operating range. The regulations also require application of a general performance correction. This correction considers climb performance capability and the associated effect on noise levels.

Suggested changes to Chapter 6 of ICAO Annex 16 and FAR Part 36 Appendix F would substitute a takeoff test for the current flyover test. Along with this change comes the need to develop reliable correction procedures for changes in noise level which accompany non-reference helical tip Mach Number, non-reference engine power levels, and non-reference altitudes.

In an effort to assess the proposed revision, takeoff noise measurements were made for 18 aircraft. Additional measurements for nine of these aircraft during level flyover provided sufficient data to examine the relationship of noise levels versus variations in helical tip Mach Number and engine power setting.

Table 1 presents selected physical attributes for each of the test aircraft, while Table 2 lists the reference takeoff performance characteristics for each airplane. The parameters shown in Table 2 are used for normalizing test measurement data to reference takeoff performance and meteorological conditions.

TABLE 1.1

GENERAL AVIATION AIRCRAFT SPECIFICATIONS
1982 NOISE TEST; DULLES INTERNATIONAL AIRPORT

| | Engine(s) | | | | | | | Propeller | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Aircraft | Model | Max Cont Pwr (total) | Prop Shaft RPM | Manifold Press/T | Number Engines | Engine Type | Air Intake | Model | Number Blades | Dia | Pitch | Wing Span (ft) | Gear Fixed/ Retractable |
| Cessna 180 | Continental 0-470-L | 230hp | 2550 | 27.5 | 1 | piston | normally aspirated | McCauley | 2 | 82.2" | var | 36.0' | F |
| Archer II PA-28 181 | Lycoming 0-360 | 180hp | 2700 | fixed pitch | 1 | piston | normally aspirated | Sensenich | 2 | 76" | fixed | 35.0' | F |
| Turbo ArrowIV PA28RT 201T | Continental TSIO-360 | 200hp | 2575 | 41" | 1 | piston | turbocharged | Hartzell | 3 | 76" | var | 35.4' | R |
| Tomahawk PA-38-112 | Lycoming 0-235 | 112hp | 2350 | fixed pitch | 1 | piston | normally aspirated | Sensenich | 2 | 72" | fixed | 34.0' | F |
| Cessna 170 | Continental 0-300C | 145hp | 2375 | fixed pitch | 1 | piston | normally aspirated | Sensenich | 2 | 76" | fixed | 36.0' | F |
| King Air 200 | P&W PT6A-41 | 850shp | 2000 | 2230 (Torque) | 2 | turboprop | compressor stages | Hartzell | 3 | 98 5' | var | 54.5' | R |
| Cheyenne PA-42 | P&W PT6A-41 | 720shp | 2000 | 1985 (Torque) | 2 | turboprop | compressor stages | Hartzell | 3 | 95" | var | 47.7' | R |
| Chancellor C-414 | Continental TSI0-520 | 310 | 2700 | 39.5" | 2 | piston | turbocharged | McCauley | 3 | 76.5" | var | 44.7' | R |
| Baron B58-P | Continental TSI0-520-WB | 325hp | 2700 | 39.5" | 2 | piston | turbocharged | Hartzell | 3 | 78" | var | 37.8' | R |
| Centurion C-210 | Continental 10-520-L | 300hp | 2700 | 30" | 1 | piston | normally aspirated | McCauley | 3 | 80" | var | 36.8' | R |
| Skylane C-182 | Continental 0-470 | 230hp | 2400 | 31" | 1 | piston | normally aspirated | McCauley | 3 | 79" | var | 35.8' | R |
| Skyhawk C-172 | Lycoming 0-320 | 160hp | 2300 | fixed | 1 | piston | normally aspirated | McCauley | 2 | 75" | fixed | 36.0' | F |
| Merlin 227-AT | Garrett TPE-331-11U | 1000shp | 1591 | 3301 (Torque) | 2 | turboprop | compressor stages | Dowty-Rotol | 4 | 106" | var | 57.0' | R |
| Gulfstream Commander900 | Garrett TPE-331-5 | 712shp | 1591 | - | 2 | turboprop | compressor stages | Dowty-Rotol | 3 | 106" | var | 52.1' | R |
| Beech Duchess | Lycoming 0-360 | 180hp | 2700 | 29" | 2 | piston | normally aspirated | Hartzell | 2 | 76" | var | 38.0' | R |
| Beech BonanzaA-36 | Continental 10-520 | 235hp | 2700 | 29" | 1 | piston | normally aspirated | McCauley | 3 | 80" | var | 33.5' | R |
| Piper Navajo 350 | Lycoming T10-540 | 340hp | 2525 | 41" | 2 | piston | turbocharged | Hartzell | 3 | 80" | var | 40.7' | R |
| Cessna Conquest I C-425 | P&W PT6A-112 | 450hp | 1900 | 1244 (Torque) | 2 | turboprop | compressor stages | McCauley | 3 | 93.4" | var | 44.1' | R |

TABLE 1.2

REFERENCE TAKEOFF

CONDITIONS

| Aircraft | Max Gross T/O Wt (lbs) | T/O Ref Mach No. | $D_{50}$(ft) | Sea Level Std Day Vy(kt) | Sea Level Std Day Max Climb Rate (feet per minute) | Climb Angle (degrees) | Ref* Alt (ft) |
|---|---|---|---|---|---|---|---|
| Cessna 180 | 2800 | .8271 | 1205 | 76 | 1100 | 8.2 | 1058 |
| Archer II PA-28 181 | 2550 | .7074 | 1860 | 76 | 735 | 5.5 | 658 |
| Turbo Arrow IV PA28RT 201T | 2900 | .7789 | 1620 | 97 | 940 | 5.5 | 682 |
| Tomohawk PA-38 112 | 1680 | .6697 | 1460 | 70 | 718 | 5.8 | 736 |
| Cessna 170 | 2000 | .7151 | 1850 | 77.3 | 760 | 5.6 | 669 |
| King Air 200 | 12500 | .7932 | 2579 | 126 | 2450 | 11.1 | 1149 |
| Cheyenne PA-42 | 11200 | .7645 | 3220 | 120 | 2400 | 11.4 | 1052 |
| Chancellor C414 | 6750 | .8236 | 2592 | 108 | 1520 | 8.0 | 837 |
| Baron B58-P | 6200 | .8413 | 2643 | 115 | 1475 | 7.3 | 759 |
| Centurion C-210 | 3800 | .8571 | 2030 | 98 | 950 | 5.5 | 643 |
| Skylane C-182 | 3100 | .7529 | 1570 | 88.2 | 1040 | 6.7 | 827 |
| Skyhawk C-172 | 2300 | .6839 | 1625 | 76 | 700 | 5.2 | 650 |
| Merlin 227-AT | 14500 | .6959 | 3760 | 147.0 | 2330 | 9.1 | 752 |
| Gulfstream Commander 900 | 10700 | .6901 | 1850 | 130 | 2840 | 12.4 | 1452 |
| Beech Duchess | 3900 | .8155 | 2119 | 97.5 | 1248 | 7.3 | 824 |
| Beach BonanzaA-36 | 3400 | .8564 | 2041 | 95 | 1036 | 6.2 | 717 |
| Piper Navajo 350 | 7000 | .8195 | 2780 | 101 | 1390 | 6.3 | 830 |
| Cessna Conquest I C-425 | 8200 | .7151 | 2341 | 115 | 2027 | 10.0 | 1085 |

*8200 ft (2500m) from brake release

2.0 Aircraft Operations: Reference Conditions - For purposes of this series of tests, a reference ground track was defined as a line parallel to, and fifty feet west of the edge of Runway 36 at Dulles. The test program was structured to accommodate either a north or a south traffic flow.

2.1 North Operations - In the case of a northbound traffic flow, it was necessary to use a simulated takeoff procedure. Calculations were made to determine the ground location and altitude to intercept the climbout path. The resulting altitude achieved over the North measurement location (Site 2) theoretically would equal the reference takeoff altitude.

2.2 South Operations - In the case of southbound traffic flow, a full stop takeoff procedure was utilized with brake release at a point nominally 8200 feet (2500 meters) from the south measurement location (Site 1). The full stop takeoff procedure has been specified in the proposed noise certification test as follows:

First phase

a. takeoff power shall be used from the brake release point to the point at which the height of 50 ft (15m) above the runway is reached.

b. a constant takeoff configuration selected by the applicant shall be maintained throughout this first phase.

Second phase

a. the beginning of the second phase corresponds to the end of the first phase.

b. the aircraft shall be in the climb configuration with landing gear up, if retractable, and flap setting corresponding to normal climb throughout this second phase.

c. the speed shall be the best rate of climb speed Vy.

d. The maximum continuous power and RPM that can be delivered by the engine or engines in this flight condition shall be maintained throughout the second phase (unless a lower limiting power is established by the certificating authority,.

2.3 Level Flyovers - In both cases (north or south traffic flow), level flyover operations were conducted in concert with the normal traffic flow. In each level flyover test, target values were specified for altitude, propeller RPM, and engine power.

2.4 Reference Meteorological Conditions for Calculating Reference Takeoff Altitudes - the following paragraph, taken from the proposed takeoff noise certification standard, specifies reference meteorological conditions:

The airplane reference flight procedures shall be calculated under the following atmospheric conditions.

a. sea level atmospheric pressure of 1013.25 hPa (1013.25mb);

b. ambient air temperature of 15°C;

c. relative humidity of 70 percent; and

d. zero wind.

3.0 Acoustical Data - This section describes the procedures used in measurement, recording and reduction of acoustical data.

3.1 Measurement Locations - Two noise measurement sites were utilized during takeoff and level flyover conditions. The sites were located on the flight track centerline, 3000 feet (914m) apart on level ground with short clipped grass. The full-stop takeoff measurement site was approximately 9000 feet from the start of takeoff roll. In the case of full stop takeoff and in the case of flight path intercept takeoff, noise data were corrected to values which would be expected at a distance of 8200 feet from brake release. A schematic of the test array is shown in Figure 3.1.

3.2 Measurement Instrument - Each noise measurement site utilized two identical microphone-preamp systems situated 12" apart. The systems consisted of General Radio one-half inch electret microphones (1962-9610) driving General Radio P-42 Preamplifiers, with the microphones oriented for grazing incidence and mounted 4 feet (1.2m) above the ground. A three-inch windscreen covered each microphone. A 100-foot (30.5m) cable connected one microphone system with a General Radio 1988 Precision Integrating Sound Level Meter driving a Metrosonics Graphic Level Recorder (GLR). The other microphone system was connected by a 100-foot (30.5m) cable to a two-channel Nagra IV-SJ Magnetic Tape Recorder. Amplification was provided by Ithaco Model 451 Amplifier. Data were recorded simultaneously on both channels in the linear mode; however, on windy days, one channel was A-weighted in order to increase the signal-to-noise ratio. Measurement instrumentation schematics are shown in Figures 3.2 and 3.3.

3.3 Noise Data/Data Reduction - The 1988 system provided ALM, SEL, Equivalent Sound Level (Leq), and the duration of the integration. The 10-dB-down duration time was scaled from the Graphic Level Recorder time history charts. The data from the magnetic tape recorder system were processed using a General Radio 1995 1/3 octave real time analyzer interfaced to a PDP 11/05 computer system. It provided ALM, SEL, 10-dB-down duration, time of ALM, one-third octave spectrum for ALM, and one-half second average AL values encompassing the entire 10-dB-down time history.

The 1988 systems were the primary measurement instruments and generated the data presented in the appendices of this report. The magnetic tape recorder systems were deployed selectively on a limited number of days at certain measurement sites. As explained in subsequent sections, the tape recorder systems were utilized for the express purpose of evaluating complex versus simplified data correction procedures to account for non-standard atmospheric absorption.

Summary tables of acoustical measurements data are provided in Appendix A (Takeoff) and Appendix B (Level Flyover).

## Microphone and Acoustical Measurement Instrumentation Deployment

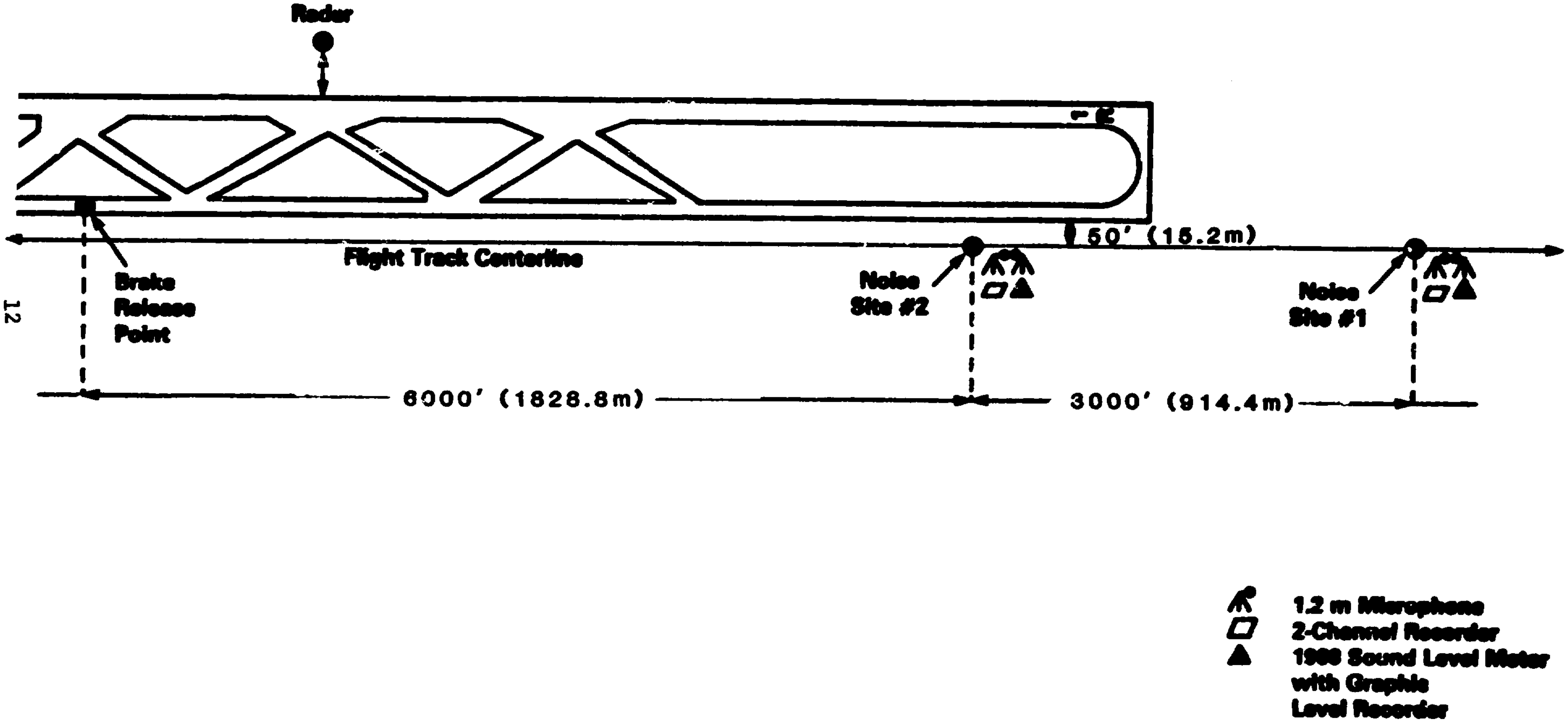
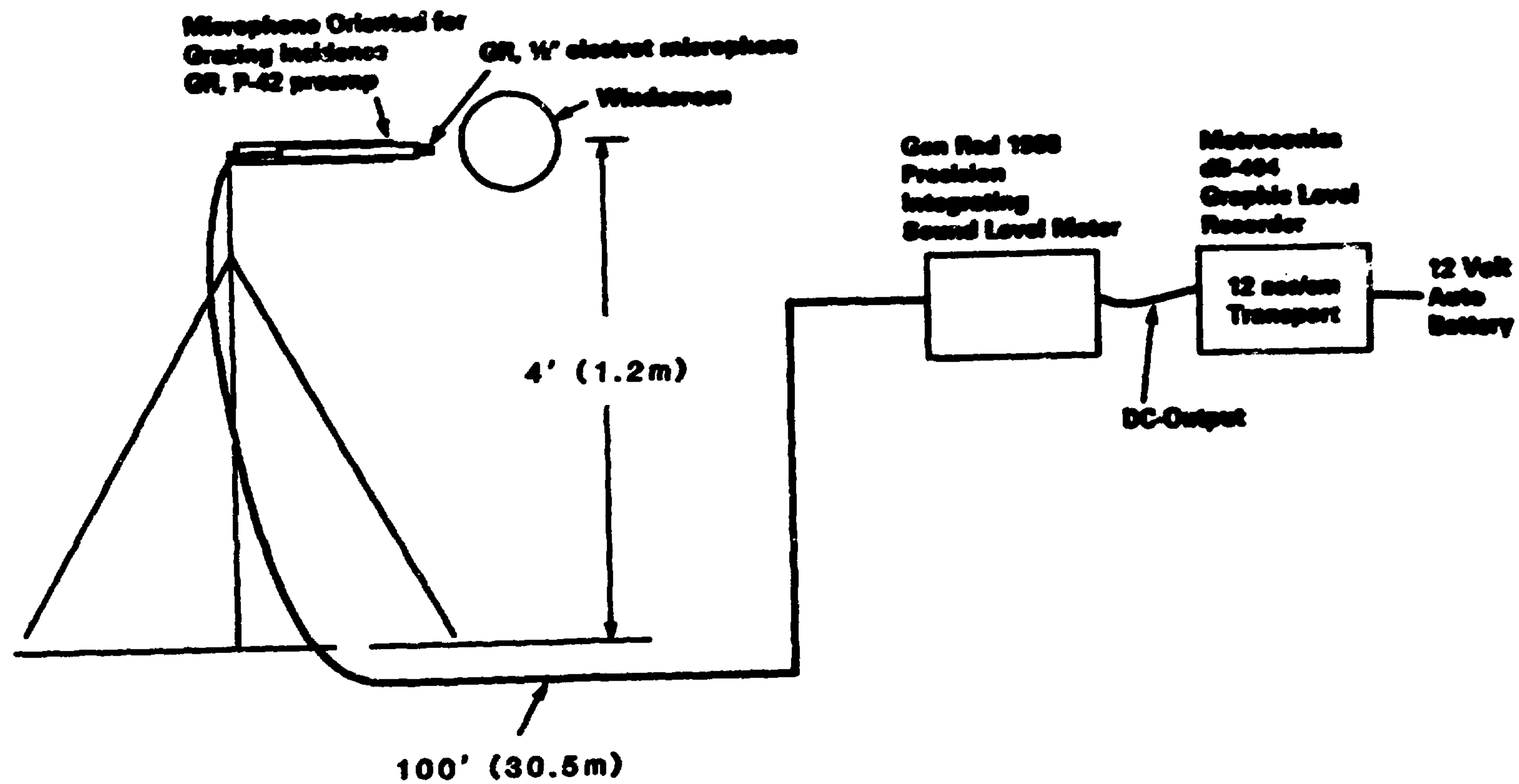



FIGURE 3.1

## 1988/GLR Direct Read

## Acoustical Measurement Instrumentation




Noise Measurement Systems

FIGURE 3.2

## NAGRA Tape Recorder

## Acoustical Measurement Instrumentation

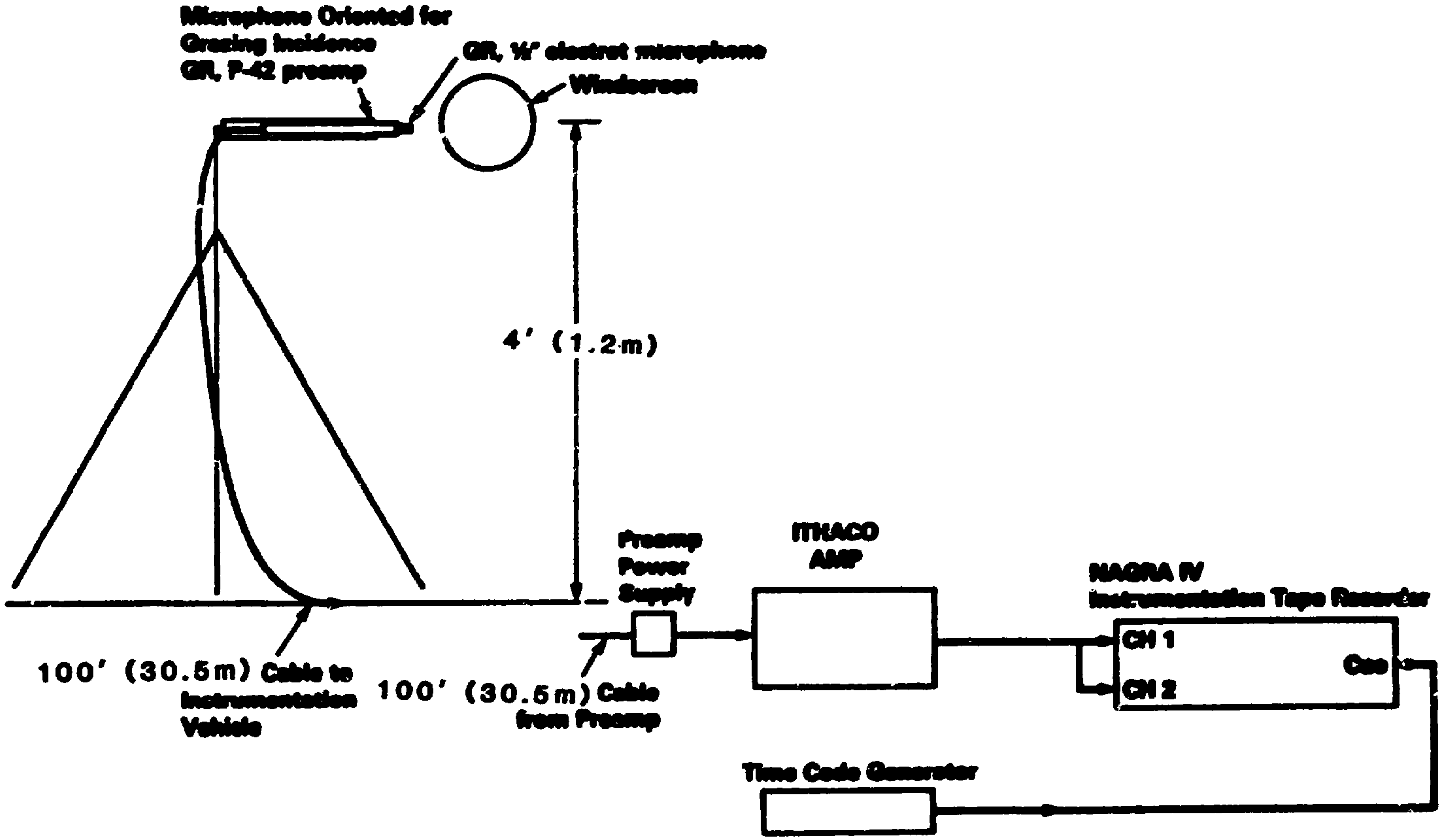



FIGURE 3.3

4.0 Meteorological Data - On-site measurements were taken approximately every 1/2 hour using a sling-psychrometer to measure air temperature and relative humidity. Wind was monitored constantly using a three-cup anemometer.

The U.S. National Weather Service provided upper air observations from routine Radiosonde launchings at nearby Sterling, Virginia. FAA personnel also monitored the wind information provided by the Dulles Low-Level Wind Shear monitoring system.

A tabulation of meteorological data is provided in Appendix D of this report.

5.0 Aircraft Position Data - Aircraft position relative to the reference flight track and noise measurement sites was determined using three different techniques; radar, photoscaling and transit.

A brief description of each technique is provided below:

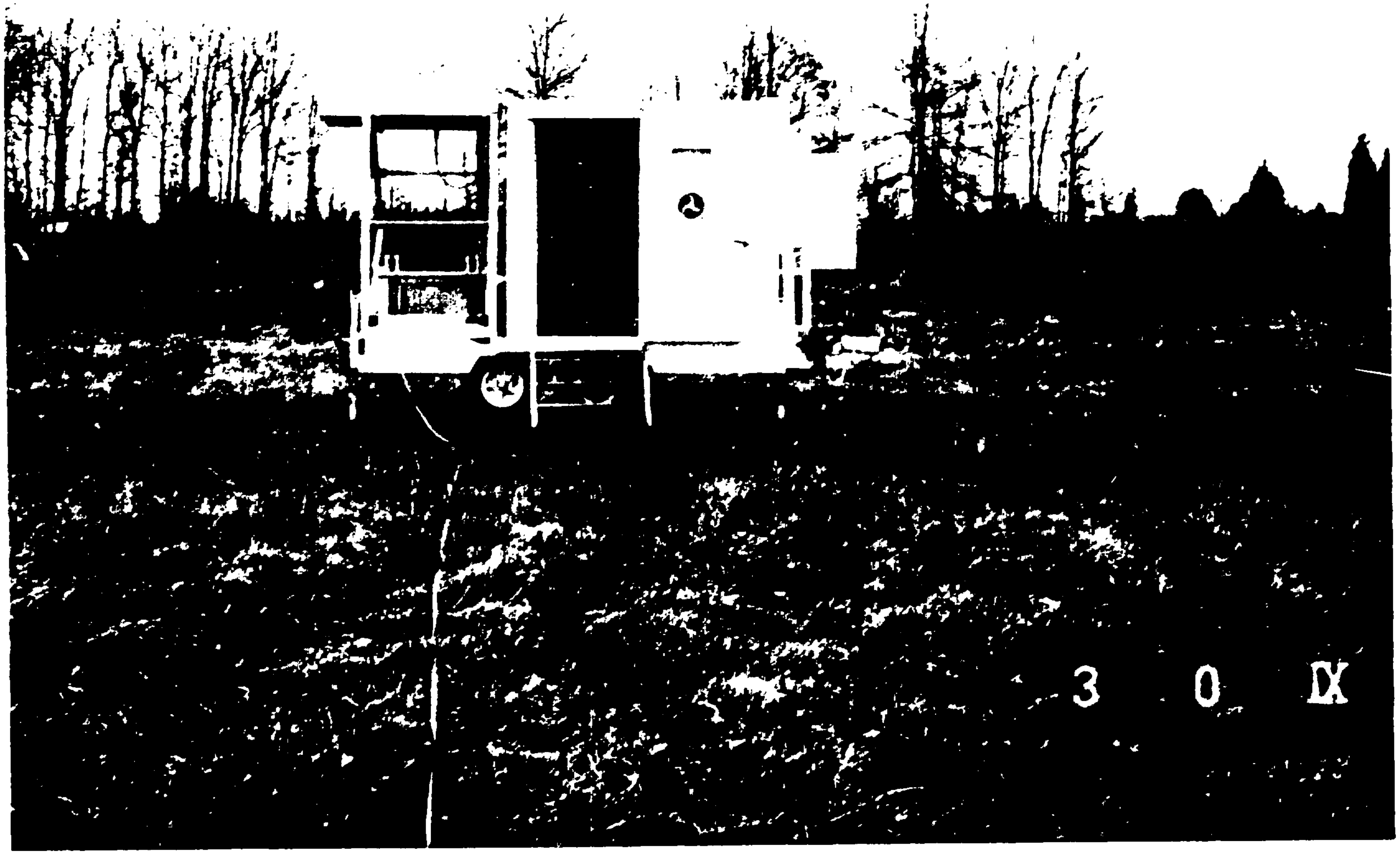
Photo-Scaling - 35mm photographs were taken of each aircraft as it passed over the noise site. Each image was measured and compared with an appropriate calibration photograph to determine altitude.

Radar - Aircraft position data were supplied, for some events, by a tracking radar system. A photograph of the radar system is shown in Figure 5.1.

Transit - A surveyor's transit was placed approximately 1500' (457m) abeam (east) of the primary noise site. The observer visually followed the target aircraft through the transit until the aircraft passed over the noise site (transit turret was blocked from moving beyond the noise site). An elevation reading was taken to determine the aircraft's altitude above the noise site. This method was included in the test program merely to evaluate its feasibility. None of the transit data was used in the analyses presented in this paper.

The three different measurement systems were used, in part, for the purpose of evaluating comparative performance and in part, to maintain back-up tracking capability. A comparative analysis is provided in sections which follow.

The aircraft position data used in level flyover analyses (see Appendix B) were primarily from the photo-scaling systems while radar data were primarily used in evaluating takeoff noise data (see Appendix A). This methodology reflects the timing and sequence of data analysis as well as delays encountered in developing radar data reduction software.




RADAR PHOTOGRAPH
FIGURE 5.1

6.0 Cockpit Instrument Readings - Cockpit data were logged by an FAA observer for each noise run when the aircraft was approximately over the (proposed) noise certification measurement location. These data were essential for developing and (in the case of takeoff), applying propeller tip speed corrections and power corrections. A tabulation of the acquired cockpit data is presented in Appendix C.

7.0 Propagation - This section of the report utilizes takeoff noise data from test runs in which aircraft position data were available at both measurement sites. An implicit assumption is that the acoustical emission characteristics of the test aircraft remain constant over the 3000 feet between sites.

7.1 Intensity metric: Propagation Effects - In the case of the intensity metric, maximum A-weighted Sound Level, the primary considerations are spherical spreading and atmospheric absorption. Adjustment for these factors is referred to as the Delta-1 correction. The Delta-1 process involves application of the spreading law plus absorption to each of the 24 one-third octave Sound Pressure Levels between 44 Hz and 11,200 Hz. The correction for most atmospheres and most spectra is given in simplified format as:

$$\Delta_1 = K(A) \log ({}^{d}1/d_2) \text{ dB}$$

where K(A) is greater than 20 and generally less than 27.

7.2 Energy Metric: Propagation Effects - In the case of the energy metric, SEL, one observes the same losses described above plus the effects of duration. In the example below we consider only distance-duration effects, assuming no change in ground speed. The change in SEL with distance can be written as:

$$\Delta = K(A) \log ({}^{d}1/d_2) + K(D) \log ({}^{d}2/d_1)$$

or

$$\Delta = (K(A) - K(D)) \log ({}^{d}1/d_2)$$

By defining (K(A) - K(D)) = K(S), the SEL propagation constant, one can write:

$$\Delta = K(S) \log ({}^{d}1/d_2)$$

In summary, the object of this study is to determine empirical values of K(A) and K(S) using takeoff noise measurement data.

7.3 Results - A total of 30 individual takeoff noise events (encompassing six different aircraft types) have been examined. If all data are grouped as a single population, the following overall averages result:

| | N | Propagation Constant | $\sigma$ | 90% C.I. | 90% C.I. Range for True Value of "K" |
|---|---|---|---|---|---|
| K(A) | 31 | 21.1 | 4.9 | 1.5 | 22.6 to 19.6 |
| K(S) | 30 | 15.0 | 3.4 | 1.07 | 16.1 to 13.9 |

It is seen that a much greater uncertainty exists in the estimate of K(S), while the K(A) estimate appears reasonable within the context of applicable theory. As seen in the next sub-section, the K(A) estimate is largely corroborated by other similar studies.

7.4 Examination of Other Test Data - This section uses values of Delta-1 computed in previous noise tests to determine comparison values of K(A). Using available information the following calculation was made.

$$K(A) = [\text{Delta-1}] \div \log [d_1/d_2]$$

Each value of Delta-1 used in this analysis contains three components. The first term accounts for the effects of change in atmospheric sound absorption between actual and reference atmospheres. The second term accounts for the effects of atmospheric sound absorption on the change in sound propagation path length between actual and reference flight path. The third term accounts for the effects of the inverse square law on the change in the sound propagation path length.

The following values of K(A) were obtained using this method for a number of previous helicopter and general aviation aircraft noise tests as described below:

a. K(A) = 24.38, S.D. = 2.7, Sample size - 23 for seven general aviation aircraft tested in 1978.[1]

b. K(A) = 21.7, S.D. = 0.6, Sample size - 15 for four helicopters tested in 1979.[2]

c. K(A) = 23.3, S.D. = 4.0, Sample size = 30 for eight helicopters tested in 1978.[3]

7.5 Discussion - The method of determining K(A) in this paper is strictly empirical, depending entirely on measured data. The comparison technique using previously reported data employs computed values of Delta-1. These computed values are in turn dependent on the accuracy of Society of Automative Engineers Aerospace Recommended Practice -866A.[4] While the two techniques are not strictly comparable, they both provide a means for evaluating propagation decay rate. When considered together they point to the similarity of the results and lead to the conclusion that for small propeller-driven aircraft, the appropriate value of K(A) falls between 20 and 24.

Since experimental values of K(A) determined from the summer 1982 tests are slightly over 20, it can be concluded that there is little absorption taking place. This is not surprising since the test aircraft produce sounds dominant in the low frequency range (i.e., $<$260 Hz). It is worthwhile to note that some changes in acoustical emission characteristics probably take place between two sites which may account for some of the variability.

8.0 Comparison of Simplified and Complex Procedures for Considering the Effects of Atmospheric Absorption and Spherical Spreading - the new ICAO proposal would substitute takeoff noise measurements for the current level flyover measurement requirement. This proposal would also incorporate some form of combined atmospheric absorption and spherical spreading correction similar to that outlined in Annex 16/FAR Part 36 Appendix A. This complex correction is referred to as "Delta-1". One option is a "simplified" correction concept for atmospheric absorption. In this section simplified values are calculated and compared with those of the more complex Delta-1 correction procedure to determine the magnitude and significances of the differences.

8.1 Analytical Process - Computer software was developed at the FAA's Noise Lab for use in this test. One such program accepts noise, position, and weather data, calculates corrections, and computes the desired metrics. These metrics are described below:

1. Determination of As-Measured ALM - Using the spectrum of the half-second sample producing the maximum noise level, provided by the "1995" system, this software applies A-weighting constants (unless A-weighting was applied during the test) to each 1/3 octave band sound pressure level and computes the A-weighted value.

$$L_{AM} = 10 \log \left[ \sum_{i=1}^{24} \left[ \text{ANTILOG} \frac{[SPL_i + [A\text{-}Wt]_i]}{10} \right] \right]_M \qquad \text{(EQUATION 1)}$$

2. Determination of Complex Correction AL ($AL_{cx}$) - This program calculates "corrected" A-weighted value as it does ALM. However, in this case the program also computes, for each 1/3 octave band, corrections

which are added to the A-weighted SPL's to adjust for effects associated with differences between test and reference conditions.

$$L_{Acx} = 10x \log \left[ \sum_{i=1}^{24} \left[ \text{ANTILOG } \frac{[SPL_i + [A\text{-}Wt]_i + ATM_i + ABS_i + SPH_i]}{10} \right] \right] \quad \text{(EQUATION 2)}$$

The corrections applied ($ATM_i$, $ABS_i$, $SPH_i$) in the above equation are defined as follows:

$ATM_i$ represents the standard day atmospheric correction for a particular 1/3 octave band

$$ATM_i = ((\alpha_i - \alpha_{\circ i})/1000')(ALT_T)$$

NOTE: $\alpha_i$: is the SAE-ARP-866A[6] absorption coefficient for the i-th 1/3 octave band for test day temperature and relative humidity.

$\alpha_{\circ i}$: is the SAE-ARP-866A absorption coefficient for the i-th 1/3 octave band for the reference conditions of 59°F (15°C) and 70% RH. All data have been analyzed using the 77°F, 70%RH reference conditions as well as the 59°F, 70% RH reference values. Although only the 59°F, 70% RH results are reported herein, the 77°F, 70% RH values are nearly identical.

$ALT_T$: Test altitude

$ALT_R$: Reference altitude

$ABS_i$: is the atmospheric absorption correction applied to each 1/3 octave band of the ALM spectrum.

$$ABS_i = (\alpha_{\circ i}/1000')(ALT_T - ALT_R)$$

$SPH_i$: is the correction added to the 1/3 octave band value to adjust for spherical spreading.

$$SPH_i = 20 \log (ALT_T/ALT_R)$$

This correction strictly parallels the "Delta-1" correction process contained in FAR Part 36 and ICAO Annex 16.

3. Determination of Simplified Corrected ALM ($AL_{cs}$) - To "correct the ALM value using the proposed simplified technique, this program adds as a correction factor the product of a constant (24) and the log of the ratio between the test and reference altitudes.

$$LA_{cs} = L_{AM} + 24 \log (ALT_T/ALT_R) \qquad \text{(EQUATION 3)}$$

NOTE: The value 24 has been derived from previous empirical studies of noise propagation characteristics. For further discussion please refer to Section 12.5.

4. "As Measured" Sound Exposure Level ($SEL_{AM}$) - The A-weighted values for each half-second sample (provided by the "1995" system) were used to compute the "as measured" SEL.

$$L_{AE_{AM}} = 10 \log \left[\sum_{i=1}^{n} \text{ANTILOG } [L_{A_i}/10]\right] - 3\text{dB} \qquad \text{(EQUATION 4)}$$

NOTE: The correction of 3 dB normalizes the value to a one-second base.

5. Complex Corrected Sound Exposure Level ($SEL_{cx}$) - The "corrected" SEL was calculated by adding to the $AL_{cx}$ values an "as measured" duration correction ($SEL_{AM}$-$AL_{AM}$) along with an altitude duration correction, $7 \log (ALT_R/ALT_T)$. In this analysis it is assumed that test and reference velocities are equal.

$$L_{AE_{cx}} = LA_{cx} + (L_{AE_{AM}} - L_{AM(am)}) + 7 \log (ALT_R/ALT_T) \qquad \text{(EQUATION 5)}$$

6. <u>Simplified Corrected Sound Exposure Level ($SEL_{cs}$)</u> - The simplified version for determining a corrected SEL is the same as the $SEL_{cx}$ procedure, except the value $AL_{cx}$ is replaced with the value $AL_{cs}$

$$L_{AEcs} = L_{A_s} + (L_{AE_{AM}} - L_{AM_{(am)}} + 7 \log (ALT_R/ALT_T) \quad \text{(EQUATION 6)}$$

NOTE: Use of the constant 7 in the above equations (5 and 6), rather than the value of 10, was found to provide a better fit to the test data. (see Section 9.2).

8.2 <u>A Parametric Analysis of Complex versus Simplified Differences</u> - The "Delta-1" process described above incorporates corrections for the influence of non-reference temperature and relative humidity operating over some finite "Correction Ratio", the test altitude divided by the reference altitude ($ALT_T/ALT_R$). As discussed in later sections the "Altitude is observed to be approximately equal to the "Closest Point of Approach". Therefore, in subsequent discussion the correction ratio is defined as $CPA_T/CPA_R$). This chapter attempts to explore the differences between simplified and complex correction procedures taking into account the three variables 1) temperature, 2) relative humidity, and 3) correction ratio.

This analysis uses takeoff noise spectra for test aircraft measured over a wide range of temperature (T) and relative humidity (RH) conditions.

For each spectrum acquired at a given T, RH, and test altitude, the following corrections are developed:

1. Correct to 77°,70% using simplified procedures for a series of reference altitudes resulting in Correction Ratios (CR) which span the range 0.5 to 1.5.

2. Correct to 77",70% over the same CR range using the complex procedures.

Having exercised both the complex and simplified techniques over the dimensions T,RH,CR, for a variety of representative aircraft spectra, we have plotted the differences in figure 8.1-8.10. It is observed that the complex-minus-simplified differences increase as the CR diverges from 1.0 (as one might expect), with the complex procedure yielding greater corrections (resulting in higher corrected noise levels) when CR is less than 1.0 ($CPA_T$ less than $CPA_R$). When the CR is greater than 1.0 the simplified technique yields a higher correction value resulting in a lower corrected noise level. In both cases one will find a higher corrected noise level using complex procedures.

The magnitude of this difference, however, is small (generally less than 0.5 dB) with a CR range of 0.7-1.3. As long as allowable deviations from the reference flight path are restricted to CR range of 0.7-1.3, differences between the complex and simplified Delta-1 corrections are so small that the additional time and expense of generating complex correction values is unjustified.

8.3 Atmospheric Absorption Variation with Temperature and Relative Humidity for Dominant One-Third Octave Bands. - This analysis examines which one-third octave sound pressure levels dominate the A-weighted acoustical spectrum for each aircraft. A summary of dominant and second highest bands is presented in Tabel 8-1 for typical takeoff and level flyover noise events for test aircraft. As these bands are the most influential in determining the maximum A-weighted sound level their sensitivity to atmospheric absorption is an important indicator of the need for the more rigorous "Delta-1" correction process.

# Complex versus Simplified Analysis

## Complex minus Simplified ,dB

Correction Ratio $(CPA_{TEST}/CPA_{REF}) = .5$

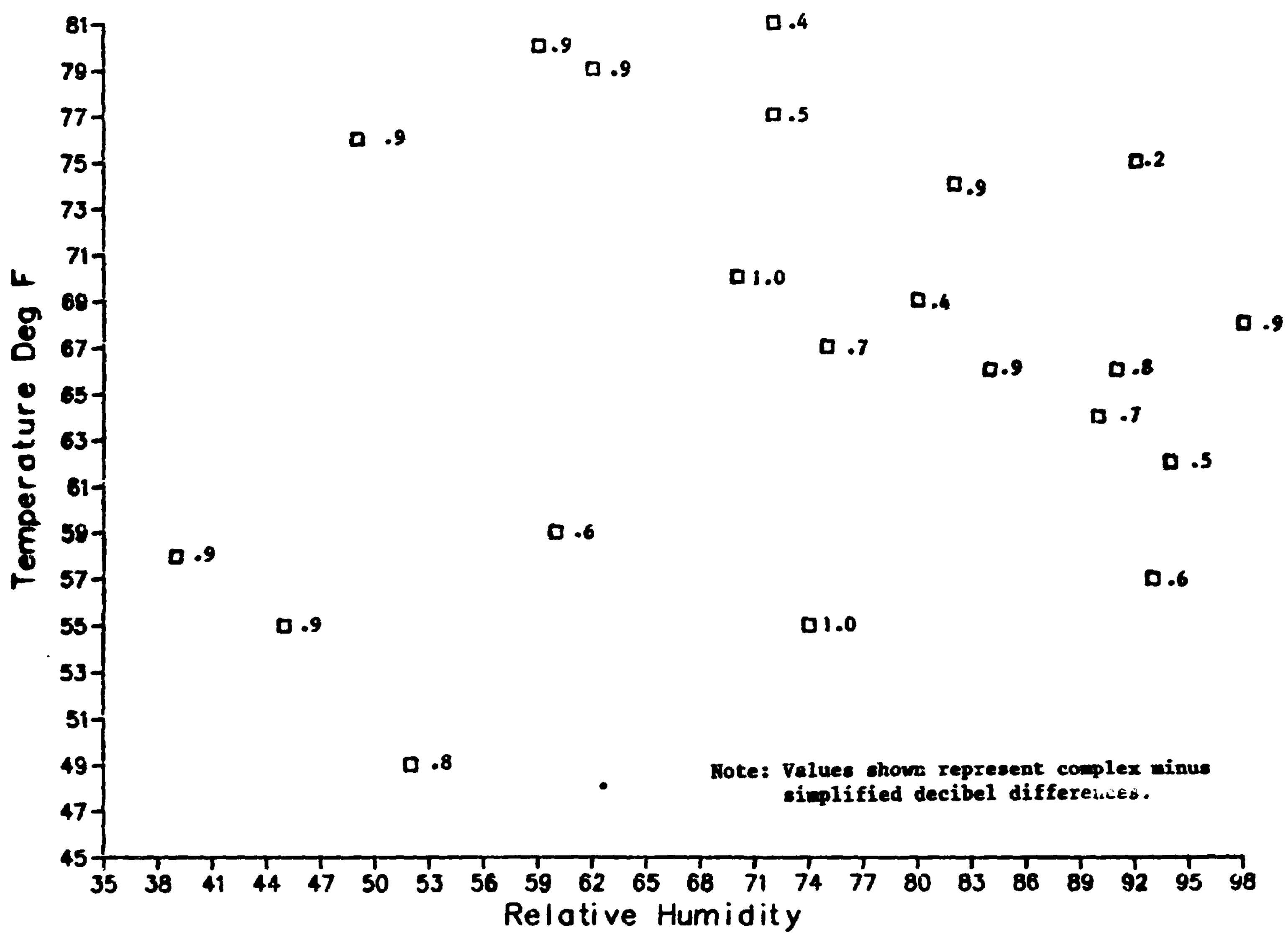



FIGURE 8-1

## Complex versus Simplified Analysis

### Complex minus Simplified ,dB

Correction Ratio $(CPA_{TEST}/CPA_{REF}) = .6$

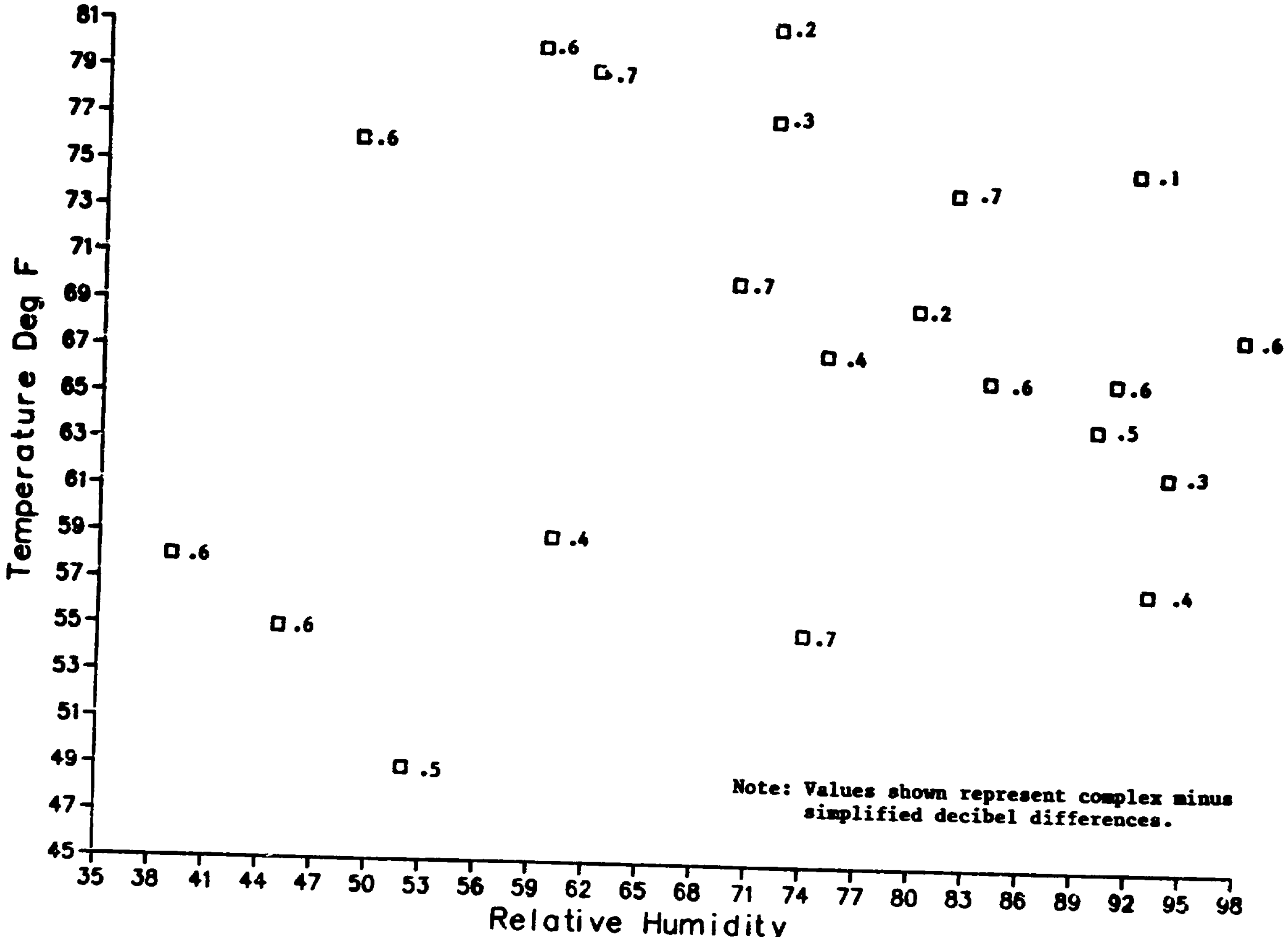



FIGURE 8-2

## Complex versus Simplified Analysis

### Complex minus Simplified ,dB

Correction Ratio $(CPA_{TEST}/CPA_{REF}) = .7$

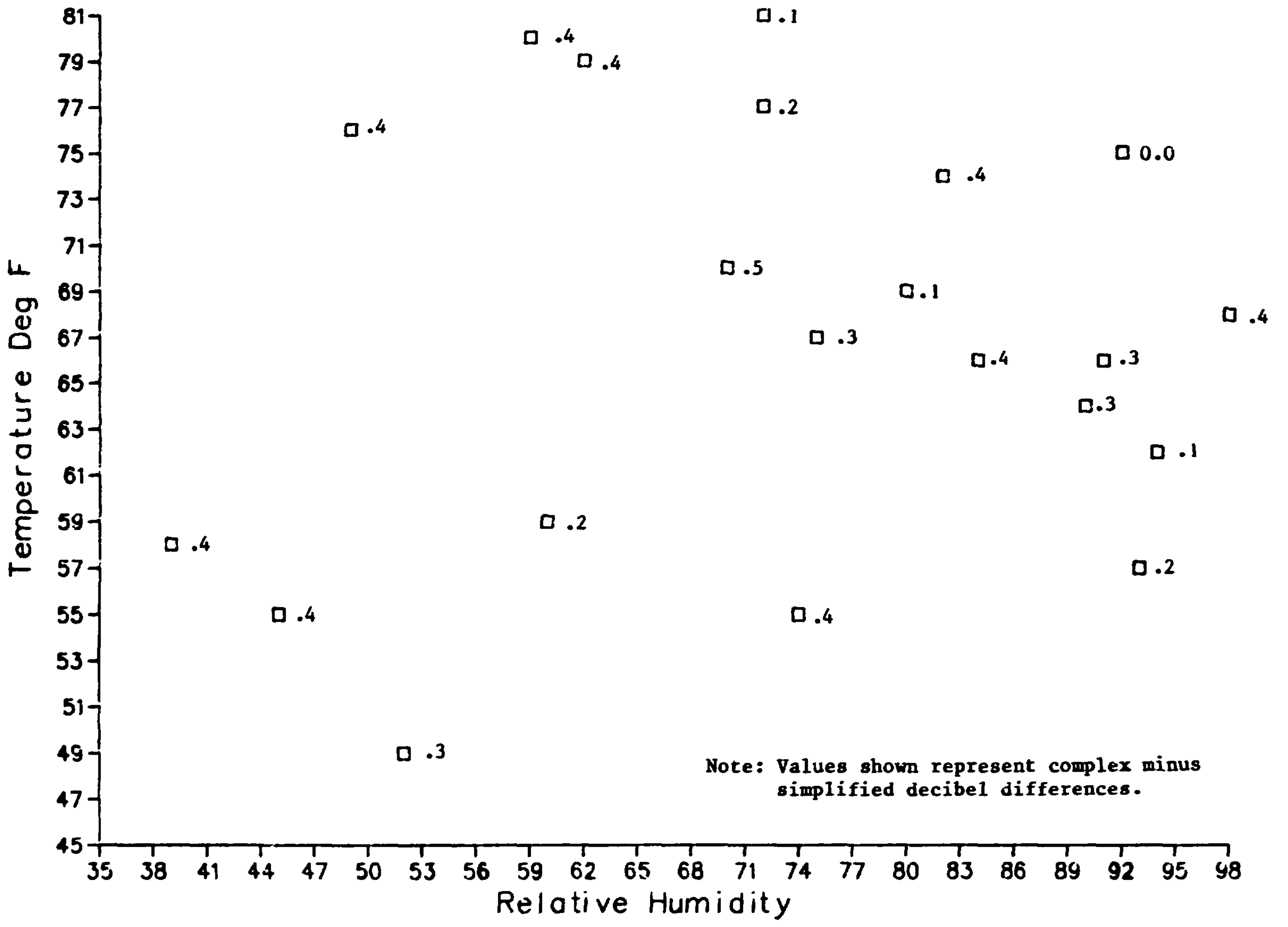



FIGURE 8-3

# Complex versus Simplified Analysis

## Complex minus Simplified ,dB

Correction Ratio $(CPA_{TEST}/CPA_{REF}) = .8$

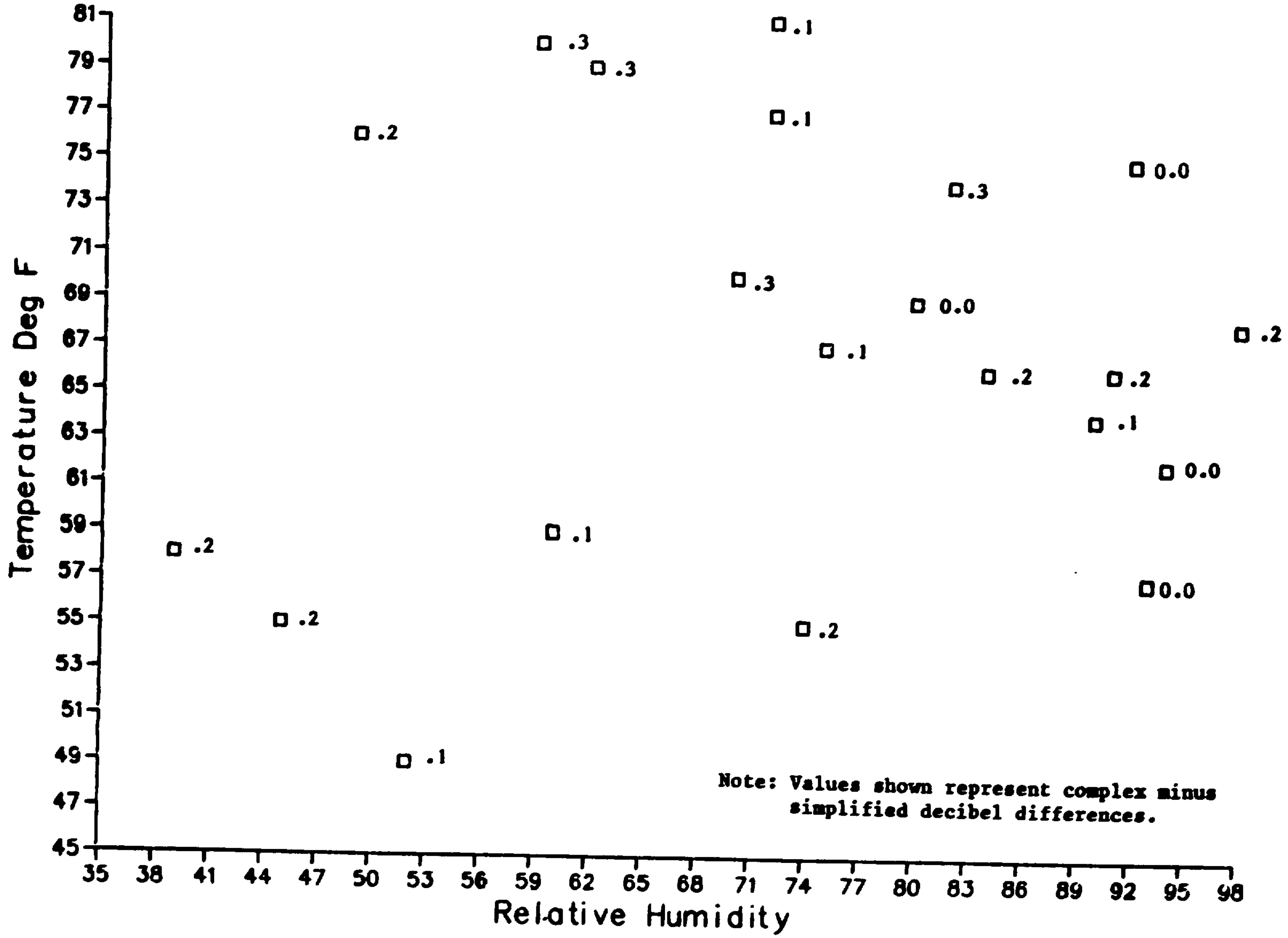



FIGURE 8-4

## Complex versus Simplified Analysis

### Complex minus Simplified ,dB

Correction Ratio $(CPA_{TEST}/CPA_{REF}) = .9$

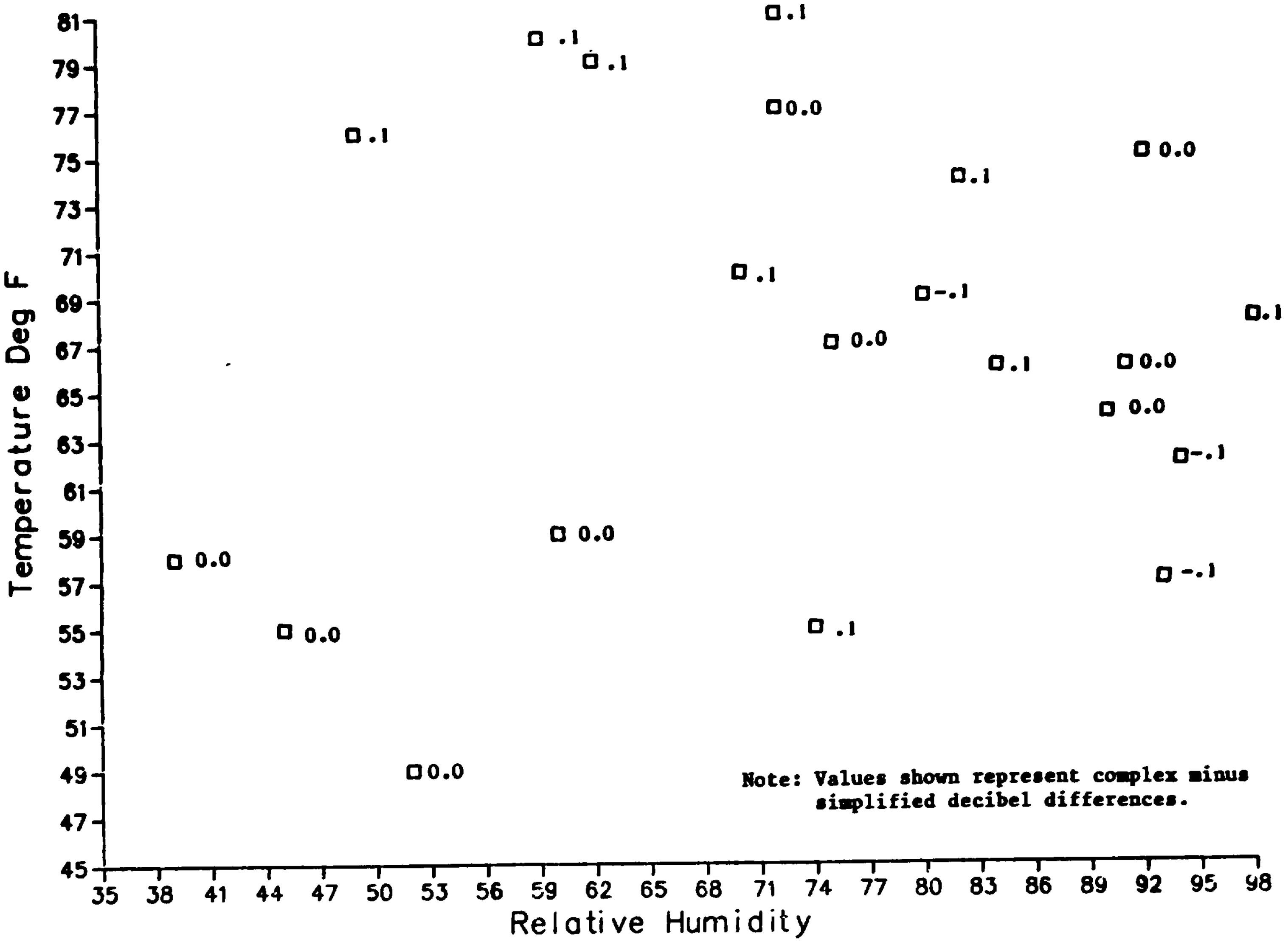



FIGURE 8-5

# Complex versus Simplified Analysis

## Complex minus Simplified ,dB

Correction Ratio $(CPA_{TEST}/CPA_{REF}) = \mathbf{1.1}$

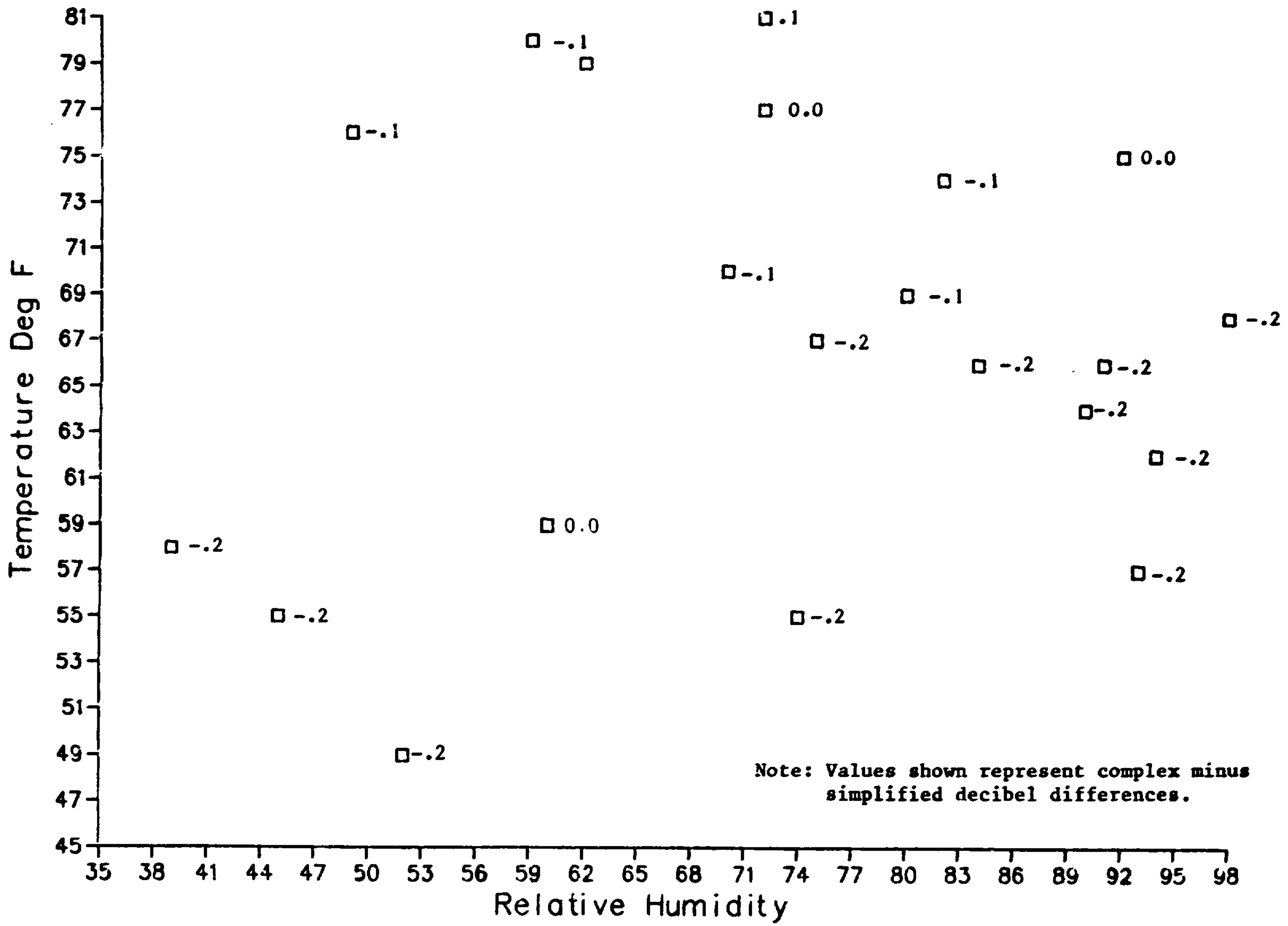



FIGURE 8-6

# Complex versus Simplified Analysis

## Complex minus Simplified ,dB

Correction Ratio $(CPA_{TEST}/CPA_{REF}) = \mathbf{1.2}$

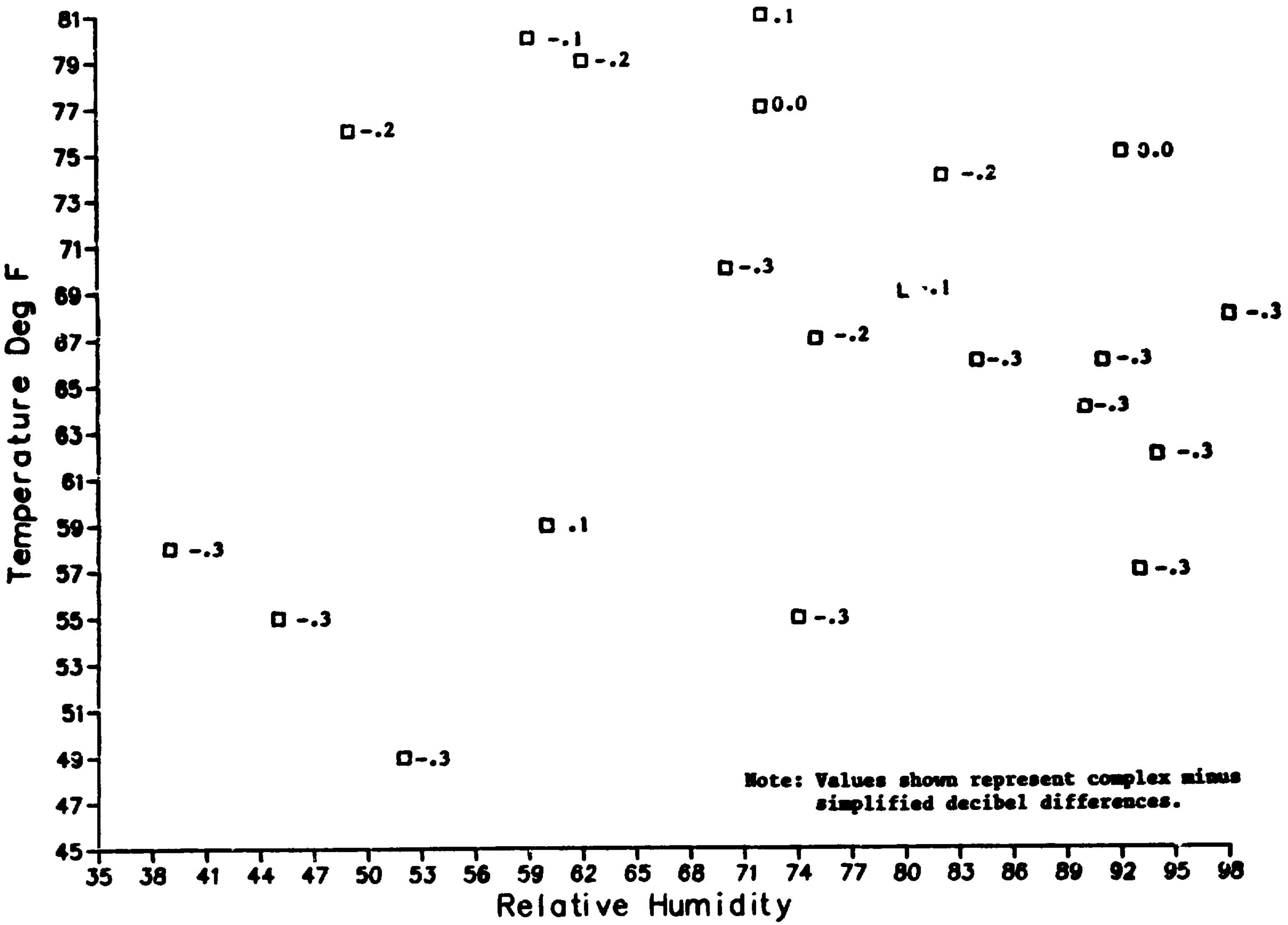



FIGURE 8-7

# Complex versus Simplified Analysis

## Complex minus Simplified ,dB

Correction Ratio $(CPA_{TEST}/CPA_{REF}) = \mathbf{1.3}$

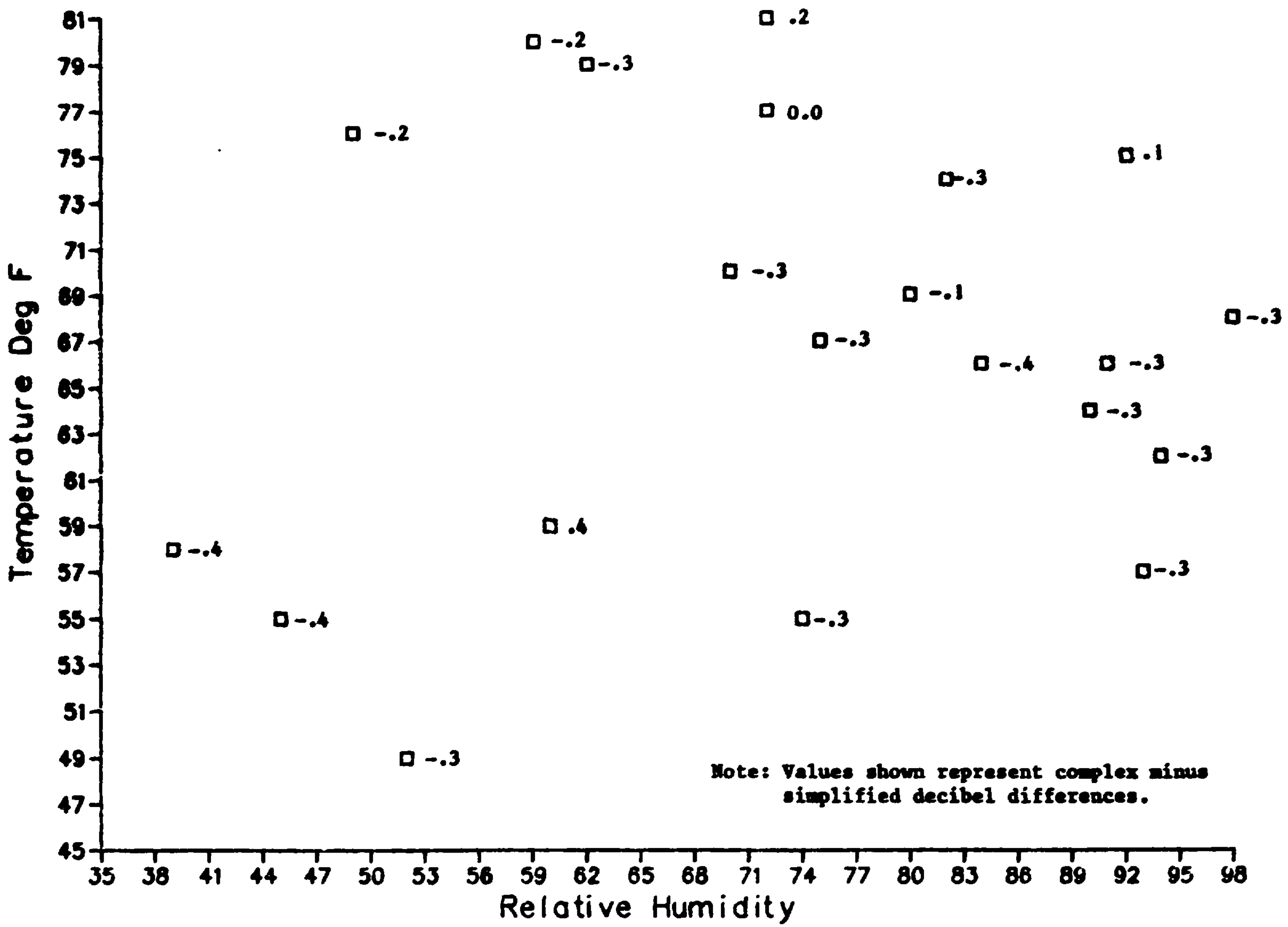



FIGURE 8-8

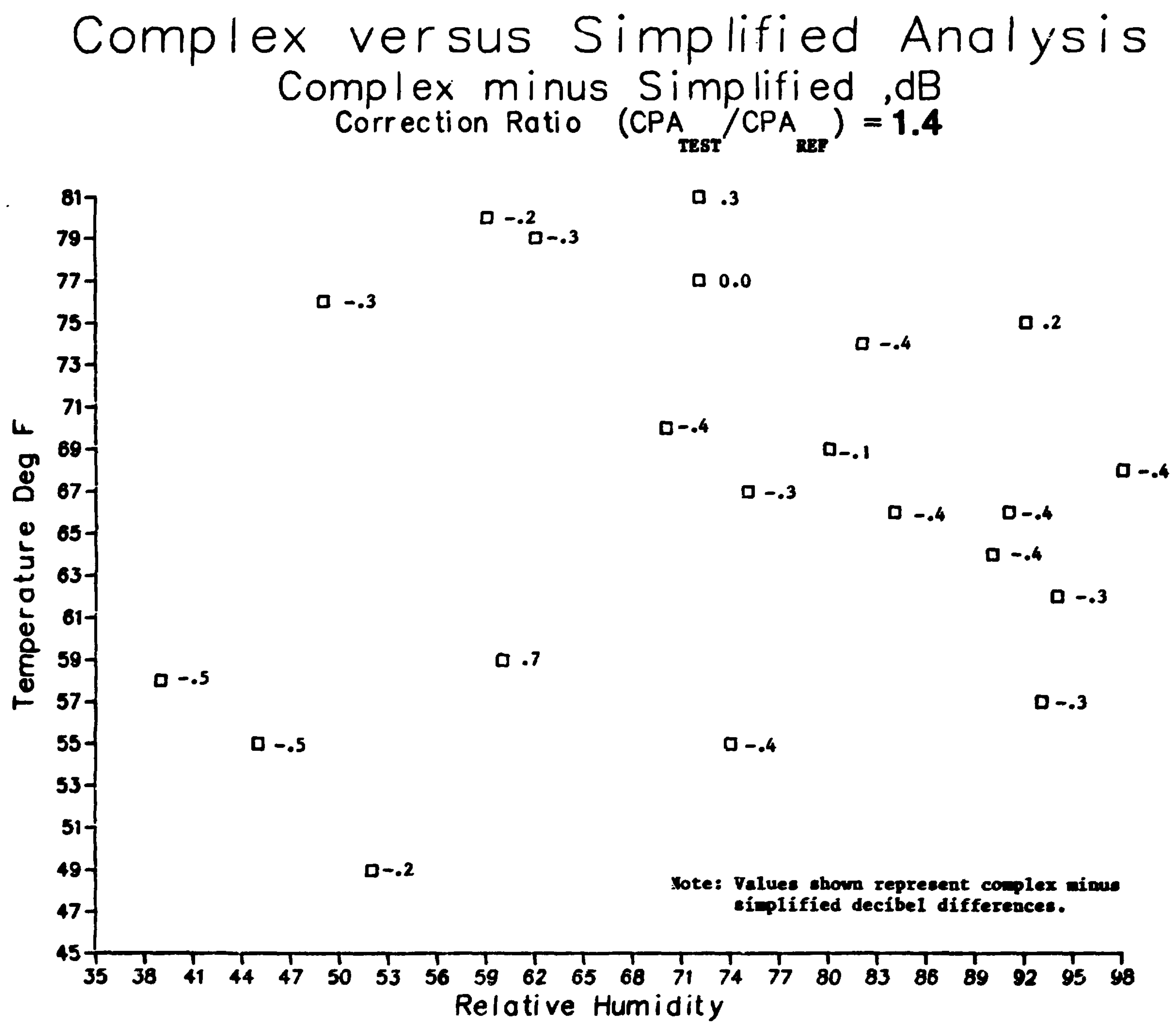

Complex versus Simplified Analysis
Complex minus Simplified ,dB
Correction Ratio ($CPA_{TEST}/CPA_{REF}$) = 1.4
Temperature Deg F
81
79
77
75
73
71
69
67
65
63
61
59
57
55
53
51
49
47
45
35 38 41 44 47 50 53 56 59 62 65 68 71 74 77 80 83 86 89 92 95 98
Relative Humidity
.3
-.2
-.3
0.0
-.3
.2
-.4
-.4
-.1
-.4
-.3
-.4
-.4
-.4
-.3
.7
-.5
-.3
-.5
-.4
-.2
Note: Values shown represent complex minus simplified decibel differences.

FIGURE 8-9

# Complex versus Simplified Analysis

## Complex minus Simplified ,dB

Correction Ratio $(CPA_{TEST}/CPA_{REF}) = 1.5$

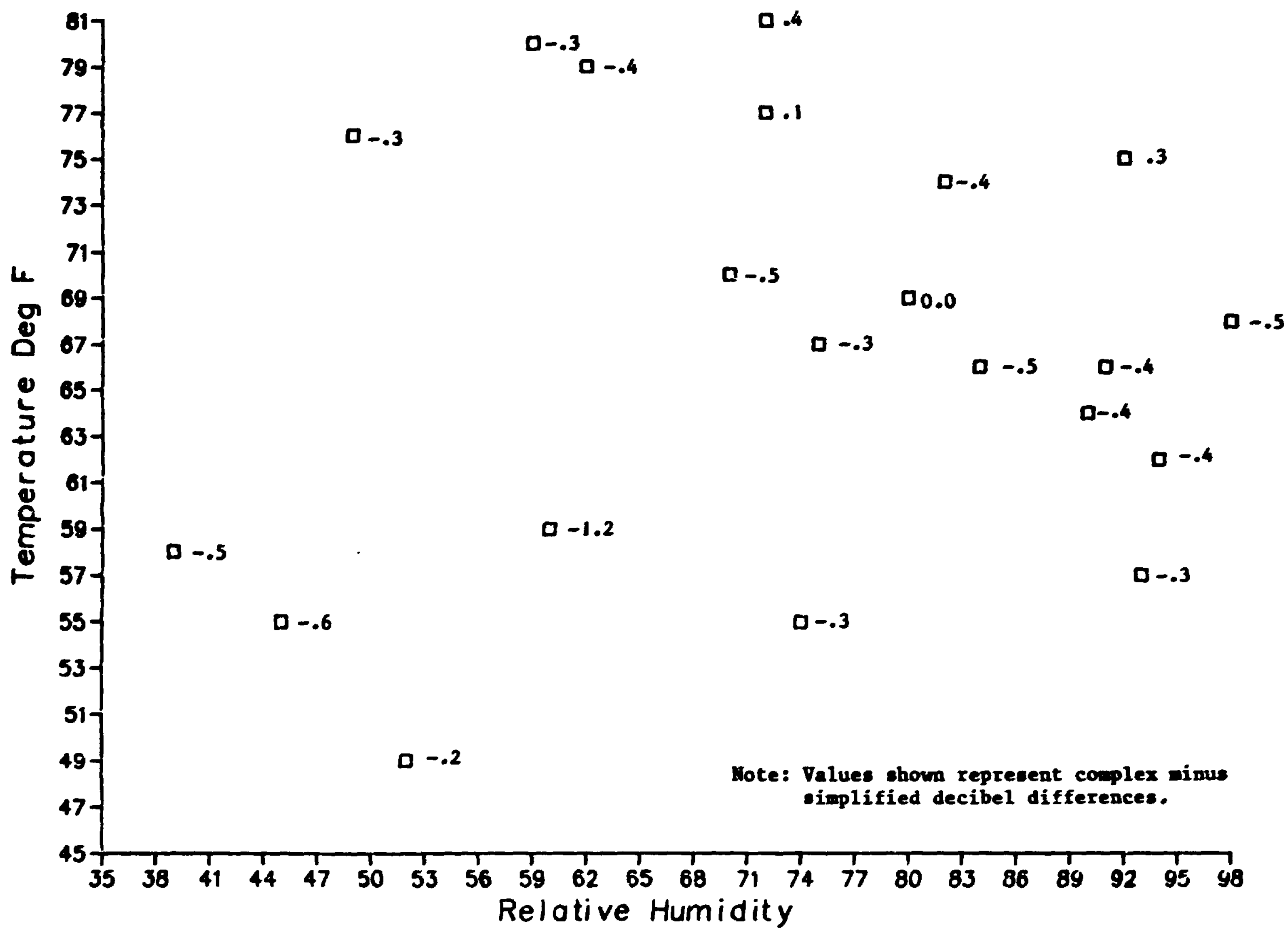



FIGURE 8-10

Having established the dominant bands one can now examine the sensitivity to absorption by inspecting Table 8-2 which provides rates of absorption for the standard acoustical day (77°F,70%) and five other T-RH combinations which encompass a realistic test condition window. In cases where a significant difference (1dB/1000') exists between the 77°F,70% rate of absorption and a selected test condition, one would expect to see greater sensitivity to atmospheric absorption in the correction process and perhaps a greater need for the complex correction procedure. Accordingly, one would expect to see a greater difference between the results of complex and simplified correction procedures. In cases where very little difference exists between reference and test rates of absorption then the need for complex procedures is diminished and one would expect good agreement between complex and simplified procedures.

This is in fact the case observed for almost all of the aircraft tested with the exception of the Duchess and Archer II which are dominated by acoustical energy in the 1 kHz to 2 kHz range.

TABLE 8-1

A-WEIGHTED ACOUSTICAL SPECTRA

DOMINANT ONE-THIRD OCTAVE BANDS

| AIRCRAFT TYPE | TAKEOFF NO. 1 FREQ (Hz) | TAKEOFF NO. 2 FREQ (Hz) | TAKEOFF dB-DOWN | LEVEL FLYOVER NO. 1 FREQ (Hz) | LEVEL FLYOVER NO. 2 FREQ (Hz) | LEVEL FLYOVER dB-DOWN |
|---|---|---|---|---|---|---|
| CESSNA 170 | 125 | 315 | 0.9 | 125 | 315 | 3.3 |
| TURBOW ARROW IV | 250 | 400 | 0.2 | 250 | 125 | 1.0 |
| TOMOHAWK | 160 | 315 | 2.3 | 160 | 315 | 1.0 |
| KING AIR 200 | 400 | 315 | 2.3 | 500 | 400 | 1.1 |
| CESSNA 414 | 125 | 630 | 3.6 | 125 | 250 | 6.5 |
| PIPER CHEYENNE | 200 | 315 | 1.7 | 315 | 100 | 3.8 |
| BARON 58P | 400 | 630 | 1.6 | 250 | 400 | 2.0 |
| CESSNA 210 | 800 | 1000 | 0.5 | | | |
| CESSNA 182 | 125 | 250 | 10.3 | | | |
| CESSNA 172 | 160 | 315 | 2.3 | | | |
| MERLIN 227AT | 20 | 125 | 1.8 | | | |
| GULFSTREAM 900 | 160 | 315 | 8.7 | | | |
| DUCHESS | 1000 | 800 | 0.5 | | | |
| ARCHER II | 2000 | 2500 | 0.5 | | | |
| CESSNA 441 | 200 | 315 | 1.8 | 315 | 250 | 3.5 |
| NAVAJO 350 | 125 | 400 | 2.7 | | | |
| BONANZA A-36 | 400 | 250 | 1.24 | | | |
| CESSNA 180 | 315 | 500 | 0.4 | 125 | 400 | 1.96 |

TABLE 8.2

ATMOSPHERIC ABSORPTION
FOR SELECTED
TEMPERATURES AND RELATIVE HUMIDITY

(dB/1000 ft.)

| FREQUENCY (Hz) | 77°F 70% | 36°F 60% | 36°F 95% | 45°F 30% | 65°F 50% | 95°F 20% | 95°F 90% |
|---|---|---|---|---|---|---|---|
| 50 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| 63 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| 80 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.2 | 0.2 |
| 100 | 0.2 | 0.1 | 0.1 | 0.1 | 0.2 | 0.2 | 0.2 |
| 125 | 0.2 | 0.1 | 0.1 | 0.1 | 0.2 | 0.3 | 0.3 |
| 160 | 0.3 | 0.2 | 0.2 | 0.2 | 0.2 | 0.3 | 0.3 |
| 200 | 0.3 | 0.2 | 0.2 | 0.3 | 0.3 | 0.4 | 0.4 |
| 250 | 0.4 | 0.3 | 0.3 | 0.4 | 0.4 | 0.5 | 0.5 |
| 315 | 0.6 | 0.4 | 0.4 | 0.5 | 0.5 | 0.7 | 0.7 |
| 400 | 0.7 | 0.5 | 0.5 | 0.8 | 0.6 | 0.9 | 0.9 |
| 500 | 0.9 | 0.7 | 0.6 | 1.1 | 0.8 | 1.1 | 1.1 |
| 630 | 1.1 | 0.9 | 0.7 | 1.5 | 1.0 | 1.3 | 1.3 |
| 800 | 1.4 | 1.3 | 0.9 | 2.2 | 1.2 | 1.7 | 1.7 |
| 1000 | 1.8 | 1.9 | 1.3 | 3.1 | 1.6 | 2.2 | 2.2 |
| 1250 | 2.2 | 2.7 | 1.7 | 4.3 | 2.0 | 2.7 | 2.7 |
| 1600 | 2.9 | 3.9 | 2.4 | 6.2 | 2.6 | 3.5 | 3.5 |
| 2000 | 3.6 | 5.6 | 3.4 | 8.5 | 3.4 | 4.7 | 4.4 |
| 2500 | 4.6 | 7.8 | 4.8 | 11.7 | 4.6 | 6.2 | 5.5 |
| 3150 | 5.9 | 11.1 | 7.0 | 16.4 | 6.3 | 8.6 | 7.1 |
| 4000 | 7.6 | 16.0 | 10.2 | 21.6 | 9.1 | 12.2 | 9.1 |
| 5000 | 8.7 | 19.0 | 12.2 | 24.3 | 10.9 | 14.7 | 10.4 |
| 6300 | 11.0 | 25.9 | 17.3 | 30.1 | 15.4 | 20.7 | 13.2 |
| 8000 | 14.9 | 36.6 | 25.0 | 37.4 | 22.7 | 30.5 | 17.2 |
| 10000 | 20.6 | 52.0 | 36.1 | 45.4 | 33.1 | 44.2 | 22.7 |

9.0 Analysis of Duration Correction Procedures - Originally, the proposed metric for evaluating takeoff noise was the Sound Exposure Level, abbreviated SEL (symbol, $L_{AE}$). This metric considers not only the intensity but also the duration of the noise event. This section develops an empirical approach to evaluating changes in SEL with changes in event duration associated with non-reference testing. However, in light of recent conclusions favoring the use of ALM rather than SEL for certification purposes, this discussion can now be considered moot.

9.1 Establishing the Relationship Between 10-dB Duration Time and Aircraft-to-Observer Distance - In order to develop this relationship it was necessary to utilize takeoff data. In this flight condition it is assumed that acoustical emission characteristics of the aircraft are nominally the same as the aircraft passes over the two measurement locations. As the two sites were separated by 3000 feet, the aircraft altitudes differed significantly. Table 9.1 depicts the results of correlation analyses between distance and duration. The high average correlation coefficient indicates that a change in distance is accompanied by a proportional change in duration. These results are consistent with theory and substantiate the assumptions inherent in the ICAO Annex 16, Distance Duration Correction Adjustment ($\Delta$ 2) procedure.

9.2 Establishing an Empirical Relationship Between SEL, AL, and 10-dB Duration Time - In order to investigate this relationship an empirical formula was developed, $L_{AE} = L_A + K(D) \times \log (T)$ and evaluated using measurement data. For selected noise events the "duration constant"

K(D) was determined. Table 9.2 is a summary of these results. As the table shows, the values are consistently between 5.7 and 7.2 with the overall average of 6.5. This suggests that the appropriate value should be somewhere in this range. These results are generally consistent with the findings of Reference 2 in which a nominal duration constant K(D) of 7.0 was observed.

This similiarity of results has led to the decision to adopt a duration constant of 7.0 as the appropriate value for duration corrections in this study.

NOTE: It is worthwhile to note that on May 13, 1983, the ICAO Committee on Aircraft Noise formally endorsed a value of 7.5 as the duration correction constant for use in aircraft noise certification and noise impact assessment.

9.3 Summary of Observations/Conclusion

a. Change in distance is proportional to change in 10-dB down duration time.

b. $L_{AE} = L_A + 7 \log$ [Duration Time].

c. Duration Correction $= 7 \log \left[\frac{DUR_1}{DUR_2}\right]$

d. Distance Duration Correction $= 7 \log \left[\frac{Dist_1}{Dist_2}\right]$

e. Assuming that the same physics which govern change in duration with change in distance apply to changes in velocity then the expression $\Delta L_{AE} = 7 \log \left[(Vg_{(T)}/Vg_{(R)})\right]$ (where $Vg_{(T)}$ is test speed and $Vg_{(R)}$ is reference ground speed) would be appropriate for establishing the velocity duration correction adjustments.

TABLE 9.1

CORRELATION BETWEEN DISTANCE
AND 10dB DOWN DURATION TIME

| AIRCRAFT | TEST DATE | R | N |
|---|---|---|---|
| C-180 | 6-3 | .943 | 4 |
| C-170 | 6-23 | .859 | 3 |
| PA-38 | 8-10 | .858 | 7 |
| KING AIR 200 | 8-31 | .956 | 6 |
| C-414 | 9-14 | .946 | 6 |
| BEECH 58-P | 9-28 | .963 | 2 |
| | | R = .921 | |

TABLE 9.2

K(DUR) SUMMARY SHEET

| AIRCRAFT | TEST DATE | AVG K(DUR) | SAMPLE SIZE |
|---|---|---|---|
| CESSNA 170 | 6-23-82 | 7.04 | 10 |
| Turbow ARROW | 7-13-82 | 6.48 | 8 |
| KING AIR 200 | 8-31-82 | 5.70 | 7 |
| CESSNA 210 | 10-5-82 | 6.3 | 6 |
| PIPER NAVAJO | 10-20-82 | 7.2 | 6 |

AVG K(DUR) = 6.5

## 10.0 Development of Propeller Tip Mach Number Correction Functions - This section describes the procedures employed in developing propeller tip Mach Number corrections along with derived correction functions for nine test aircraft.

When noise measurement tests are conducted under conditions other than those specified as reference test conditions, corrections are required to account for the resulting changes in the measured noise levels.

There are two categories of factors which significantly influence the noise levels of small propeller-driven aircraft and give rise to the need for corrections: 1) test flight procedures and 2) non-standard environmental conditions.

### 10.1 Influences on Helical Tip Mach Number - Figure 10.1 shows a schematic representative of the factors which influence helical tip Mach Number ($M_H$) and aircraft power. It is seen that in determining the $M_H$ of an aircraft, one has to consider such influences as outside air temperature, propeller RPM, and indicated airspeed ($V_{IAS}$).

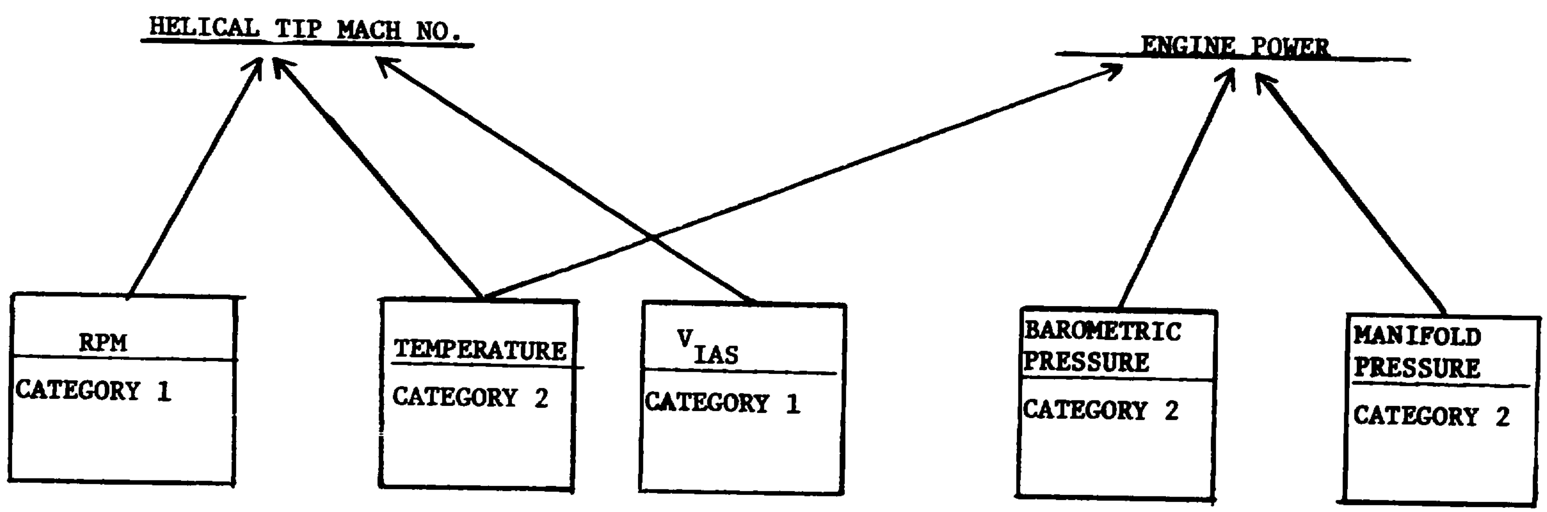
In general terms, the higher the Mach Number, the higher the noise levels produced. The following equations show the relationship of RPM, $V_{IAS}$, and air temperature in determining aircraft helical tip Mach Number.

(1) $M_H = \frac{(V_R^2 + V_T^2)^{1/2}}{c}$ $\quad V_T = V_{IAS}$ (kts.) x 1.689

(2) where $V_R = \frac{\text{Prop Dia. (in) x RPM}}{229.18}$

(3) $c = 49.02 \times (T°F + 459.67)^{1/2}$

While temperature is an environmental influence, RPM and airspeed are influences governed by test flight procedures. It should be noted that usually the contribution of $V_T$ (translational velocity) is small in determining the




CAUSES OF VARIATION OF AIRCRAFT PERFORMANCE

CATEGORY #1
PILOT TEST FLIGHT PROCEDURES

CATEGORY #2
ENVIRONMENTAL CONDITIONS

INFLUENCES ON
HELICAL TIP MACH NO. AND ENGINE POWER SETTING

FIGURE 10.1

Mach Number, while the dominant components of Mach Number are the variables $V_R$ (rotational velocity) and C (speed of sound). This shows that both test flight procedures and environmental conditions can affect the noise levels produced, due primarily to an increase or decrease in helical tip Mach Number.

10.2 Removing the Influence of Other Factors - To identify the variation of noise level with Mach Number, the test program included a selected group of flights for which power was held constant while the Mach Number was varied by varying propeller RPM and airspeed.

The first step involves normalizing all variables within the data set except the variable of interest ($M_H$). This is accomplished by correcting the "As Measured" metrics for spherical spreading, absorption, and duration differences associated with deviations from a reference altitude of 500 ft.

The intensity metric, AL, was corrected for spherical spreading and atmospheric absorption using the following equation:

$$L_A = L_A \text{ (As Measured)} + 24 \log \frac{ALT_T}{ALT_R}$$

where:

$ALT_T$ = measured test altitude.

$ALT_R$ = reference altitude (typically 500 ft).

The constant 24 accounts for spherical spreading and atmospheric absorption.

(NOTE: Upon analysis of the test data, this constant was found to be closer to the value of 22 as discussed in Section 7.0).

The energy metric, SEL, was corrected for spreading, absorption, distance-duration and velocity-duration effects using the following equation:

$$L_{AE} = L_{AE} \text{ (As Measured)} + 17 \log \frac{ALT_T}{ALT_R} + 7 \log \frac{Vg}{Vy}$$

where: Vg = ground speed determined by radar or consideration of airspeed from cockpit data logs along with radiosonde upper air wind data.

$V_y$ = speed for best rate of climb which is the reference speed for a takeoff operation.

The constant 17 accounts for spreading, absorption and distance-duration and the constant 7 accounts for velocity-duration.

10.3 <u>Determination of Noise Level - $M_H$ Relationships</u> - At this point the noise levels have been corrected for all influences except aircraft Mach Number and power setting.

It was assumed that Mach Number is related to noise level in either a linear or logarithmic fashion. The following relationships provide the appropriate mathematical models used in regression analyses.

$$L_A = K(M)_A \log (M_H) + b \qquad \text{or } L_A = K(M)_A \times (M_H) + b$$

$$L_{AE} = K(M)_S \log (M_H) + b \qquad L_{AE} = K(M)_S \times (M_H) + b$$

where $K(M)_A$ and $K(M)_S$ represent the slopes and b represents the y-intercepts of the relationships. Each equation is developed for a specific power setting, and airspeed, depicting variation of noise levels with Mach Number.

The constants $K(M)_A$ and $K(M)_S$ are used in the following manner to correct for influence of $M_H$ variation on noise levels.

$$L_{Aam} = L_{Ac} + K(M)_A \log \frac{M_{H(R)}}{M_{H(T)}}$$

$$L_{AEcm} = L_{AEc} + K(M)_S \log \frac{M_{H(R)}}{M_{H(T)}}$$

where $L_{Ac}$ and $L_{AEc}$ are the "as-measured" noise metrics corrected for distance and duration. The subscription "cm" refers to distance and duration corrected as well as Mach Number corrected noise levels.

TABLE 10-1

SUMMARY

$A_L$ v. BASE 10 LOGARITHM OF HELICAL TIP MACH NUMBER

| AIRCRAFT | EQUATION | R | %PWR | $M_H$ RANGE |
|---|---|---|---|---|
| C-170 | $L_A = 70.2 \log M_H + 86.4$ | .91 | - | .56 - .73 |
| PA-38 | $L_A = 75.8 \log M_H + 83.6$ | .95 | - | .61 - .68 |
| PA-28 | $L_A = 148.2 \log M_H + 92.2$ | .93 | 75 | .74 - .84 |
| | $L_A = 114.8 \log M_H + 88.0$ | .70 | 55 | .69 - .75 |
| C-180 | $L_A = 126.6 \log M_H + 91.5$ | .90 | 75 | .79 - .84 |
| | $L_A = 105.2 \log M_H + 87.6$ | .85 | 50 | .71 - .78 |
| BARON 58P | $L_A = 143.6 \log M_H + 95.4$ | .95 | 67 | .72 - .86 |
| C-414 | $L_A = 148.9 \log M_H + 95.6$ | .71 | 89 | .80 - .84 |
| | $L_A = 85.8 \log M_H + 89.2$ | .79 | 75 | .71 - .83 |
| | $L_A = 69.5 \log M_H + 83.7$ | .61 | 52 | .68 - .75 |
| KING AIR200 | $L_A = 53.7 \log M_H + 89.0$ | .79 | 85 | .74 - .84 |
| PA-42 | $L_A = 76.6 \log M_H + 91.8$ | .92 | 85 | .72 - .82 |
| CONQUEST 441 | $L_A = 21.5 \log M_H + 82.1$ | .36 | 90 | .68 - .76 |

10.4 Noise-Mach Number Relationships - Table 10-1 represents the results of regression analyses relating AL to the Base 10 logarithm of helical tip Mach Number. The correlation coefficient is displayed along with the equation for the line of regression, percent power (for the sample population) and $M_H$ range. Table 10-2 provides the corresponding results for linear regression analyses of AL versus Mach Number.

Table 10-3 and 10-4 present comparable analyses for the SEL metric.

10.5 Discussion - The first, and most obvious conclusion is that a negligible difference exists between results of linear and log-linear regression of noise level versus Mach Number. Further, results suggest that no single function can be universally applied. It is observed that functions for the aircraft tested lie between 20 log $M_H$ and 150 log $M_H$. However, the method of application as a correction function minimizes the net difference in correction value: $M_H$ Corr. = k log ($M_H$ ref/$M_H$ test). For a $M_H$ ratio of 1.001, (0.1 percent) the difference between 20 log ($M_H$ ratio) and 150 log ($M_H$ ratio) is only .05 dB. For a 1 percent ratio the difference increases to .56 dB and for a 10 percent ratio the difference becomes 5.4 dB. In conducting a noise certification test in accordance with acceptable window limits it would be possible to arrive at a 1.4 percent deviation in $M_H$ due to low/high temperature and/or RPM deviations.

In the absence of suitable level flyover data from which to derive a unique $M_H$ function it may be reasonable (in a conservative sense) to permit correction using the most sensitive function, 150 log $M_H$ when $M_H$ test is less than $M_H$ ref. This will relieve the applicant from the

TABLE 10-2

**SUMMARY**

**$A_L$ vs. HELICAL TIP MACH NUMBER**

**LINEAR REGRESSION**

| AIRCRAFT | EQUATION | R | %PWR | $M_H$ RANGE |
|---|---|---|---|---|
| C-170 | $L_A = 48.06\ M_H + 16.95$ | .95 | - | .56 - .73 |
| PA-38 | $L_A = 51.44\ M_H + 11.64$ | .91 | - | .61 - .68 |
| PA-28 | $L_A = 84.5\ M_H + -7.77$ | .93 | 75 | .74 - .84 |
| | $L_A = 69.96\ M_H + 1.05$ | .71 | 55 | .69 - .75 |
| C-180 | $L_A\ \ 58.04\ M_H + 17.96$ | .87 | 75 | .79 - .84 |
| | $L_A = 61.40\ M_H + 9.92$ | .85 | 50 | .71 - .78 |
| BARON 58P | $L_A = 78.79\ M_H + 2.32$ | .96 | 67 | .72 - .86 |
| C-414 | $L_A = 79.26\ M_H + 3.11$ | .71 | 89 | .80 - .84 |
| | $L_A = 48.83\ M_H + 23.55$ | .80 | 75 | .71 - .83 |
| | $L_A = 50.30\ M_H + 16.21$ | .65 | 52 | .68 - .75 |
| KING AIR200 | $L_A = 29.79\ M_H + 43.18$ | .80 | 85 | .74 - .84 |
| PA-42 | $L_A = 43.12\ M_H + 31.06$ | .93 | 100 | .72 - .82 |
| CONQUEST 441 | $L_A = 11.86\ M_H + 49.71$ | .35 | 90 | .68 - .76 |

TABLE 10-3

SUMMARY

SEL v. BASE 10 LOGARITHM OF HELICAL TIP MACH NUMBER

| AIRCRAFT | EQUATION | R | %PWR | $M_H$ RANGE |
|---|---|---|---|---|
| C-170 | $L_{AZ} = 40.7 \log M_H + 87.2$ | 0.72 | - | .56 - .73 |
| PA-38 | $L_{AE} = 72.9 \log M_H + 90.5$ | 0.88 | - | .61 - .68 |
| PA-28 | $L_{AE} = 112.5 \log M_H + 92.4$ | 0.98 | 75 | .74 - .85 |
| | $L_{AE} = 58.4 \log M_H + 86.5$ | 0.42 | 55 | .69 - .75 |
| C-180 | $L_{AE} = 75.1 \log M_H + 92.2$ | .84 | 75 | .79 - .84 |
| | $L_{AE} = 80.4 \log M_H + 90.6$ | .84 | 50 | .71 - .78 |
| BARON 58P | $L_{AE} = 88.9 \log M_H + 95.3$ | .88 | 67 | .72 - .86 |
| C-414 | $L_{AE} = 122 \log M_H + 97.6$ | .72 | 89 | .80 - .84 |
| | $L_{AE} = 43.9 \log M_H + 89.4$ | .69 | 75 | .71 - .83 |
| | $L_{AE} = 40.9 \log M_H + 86.5$ | .58 | 52 | .68 - .75 |
| KING AIR200 | $L_{AE} = 34.8 \log M_H + 90.2$ | .47 | 85 | .74 - .84 |
| PA-42 | $L_{AE} = 52.1 \log M_H + 92.3$ | .87 | 85 | .72 - .82 |
| CONQUEST I | $L_{AE} = 13.9 \log M_H + 85.0$ | .26 | 90 | .68 - .76 |

*NOTE — SEL BECOMES $L_{AE}$

TABLE 10-4

SUMMARY

SEL vs. HELICAL TIP MACH NUMBER

LINEAR REGRESSION

| AIRCRAFT | EQUATION | R | %PWR | $M_H$ RANGE |
|---|---|---|---|---|
| C-170 | $L_{AE} = 22.8\ M_H + 38.54$ | .61 | - | .56 - .73 |
| PA-38 | $L_{AE} = 52.92\ M_H + 15.73$ | .94 | - | .61 - .68 |
| PA-28 | $L_{AE} = 62.4\ M_H + 12.6$ | .98 | 75 | .74 - .85 |
| | $L_{AE} = 35.9\ M_H + 30.2$ | .43 | 55 | .69 - .75 |
| C-150 | $L_{AE} = 40.00\ M_H + 37.13$ | .84 | 75 | .79 - .84 |
| | $L_{AE} = 46.97\ M_H + 25.45$ | .84 | 50 | .71 - .78 |
| BARON 58P | $L_{AE} = 48.90\ M_H + 30.44$ | .88 | 67 | .72 - .86 |
| C-414 | $L_{AE} = 67.22\ M_H + 16.59$ | .74 | 89 | .80 - .84 |
| | $L_{AE} = 25.03\ M_H + 45.77$ | .70 | 75 | .71 - .83 |
| | $L_{AE} = 29.26\ M_H + 36.15$ | .62 | 52 | .68 - .75 |
| KING AIR200 | $L_{AE} = 19.45\ M_H + 53.84$ | .48 | 85 | .74 - .84 |
| PA-42 | $L_{AE} = 29.52\ M_H + 44.05$ | .88 | 100 | .72 - .82 |
| CONQUEST I | $L_{AE} = 7.16\ M_H + 56.09$ | .24 | 90 | .68 - .76 |

burden of additional testing and analysis, while providing motivation to be on target with performance parameters. Any deviations from reference $M_H$ due to test temperature variation higher than reference temperature can also be accounted for using the 150 log $M_H$ relationship. Additional testing should be required to derive a unique $M_H$ function for a particular aircraft when the test $M_H$ is higher than reference $M_H$ as would occur in the case of low temperature testing.

11.0 Development of Engine Power Correction Functions - This section describes the analytical procedures employed in developing engine power corrections along with the correction values derived for test aircraft.

11.1 Influences on Engine Power - Aircraft power level is another performance parameter that can have a significant contribution in determining aircraft noise levels. In Figure 10.2 we see that power is a function of temperature, barometric pressure and engine manifold pressure (or torque).

Temperature and barometric pressure fall into Category 2 (environmental conditions) influencing (thermodynamically) the internal combustion process. Engine manifold pressure (or torque) setting can be placed in Category 1, affected by test procedures.

Horsepower is related to temperature as follows:

$$H.P. = \sqrt{\frac{460 + 59°F}{460 + T°F}}$$

This equation provides approximately one percent correction for each 10°F variation from 59°F.

In the case of pressure/density effects, a simplified but reasonable approach is to assume that horsepower changes are directly related to changes in density ratio (pressure ratio).

The values can be obtained from typical standard atmosphere tables.

11.2 Analytical Methodology - Two different schemes were employed (as required) in developing Power Correction relationships: 1) using data runs that have the same Mach Number, a constant is derived which relates the change in AL to the log of the power ratio; 2) when two constant-power, noise versus log ($M_H$) functions overlap, a common Mach Number was evaluated and the change in AL was determined, from which the power correction constant was derived. These two methods are shown in the following example.

Example (Power correction constant determination)

<u>Method 1:</u> Data with same Mach No.

Data

| 75%pwr | 50%pwr |
|---|---|
| $L_{AC} = \overline{85.4}$ dB | $L_{AC} = \overline{82.3}$ dB |
| $L_{AEc} = \overline{88.4}$ | $L_{AEc} = \overline{86.9}$ |
| Vg = 166.4 mph | Vg = 139.7 mph |

$$\Delta L_A = L_{A\ 75\%} - L_{A\ 50\%} = K(P)_A \log \frac{P1}{P2}$$

$$= 85.4 - 82.3 = K(P)_A \log \frac{75\%}{50\%}$$

$$K(P)_A = 17.60$$

In the case of SEL we must make certain that we consider the effects of velocity on the noise levels, at two different power settings. Therefore, we will normalize the SEL at 50% to the ground speed of the 75% power level, as follows:

$$\text{SEL(50\% normalized to 75\% pwr Vg)} = L_{AE\,c50\%} + 7 \log \frac{139.7}{166.4}$$

$$= 86.9 + (-.53)$$

$$= 86.4$$

Then proceed as above

$$\Delta L_{AE} = L_{AE\,75\%} - L_{AE\,50\%norm} = k(P)_S \log \frac{P1}{P2}$$

$$= 88.4 - 86.4 = K(P)_S \log \frac{75\%}{50\%}$$

$$K(P)_S = 11.4$$

NOTE: Vg above is the average ground speed for the runs used in the analysis at the particular power setting.

**Method 2:** Identify two constant power (noise versus log $M_H$) functions where the Mach numbers are the same.

**Data**

89% power $\qquad V_g = 170.5$ mph

$L_A = 148.87 \log (M_H) + 95.64$

$L_{AE} = 122.17 \log (M_H) + 97.67$

75% pwr $\qquad V_g - 156.3$ mph $\qquad$ Common Mach Number = .83

$L_A = 85.82 \log (M_H) + 89.16$

$L_{AE} = 43.93 \log (M_H) + 89.13$

Substitute the common Mach Number into each of the above equations and solving yields:

| 89% pwr | 75% pwr |
|---|---|
| $L_A = 83.6$ | $L_A = 82.2$ |
| $L_{AE} = 87.8$ | $L_{AE} = 85.9$ |

Hence now we can derive a power correction constant for AL as in Method 1, as follows:

$$\Delta L_A = L_A\ 89\% - L_A\ 75\% = K(P)_A \log \frac{P1}{P2}$$

$$83.6 - 82.2 = K(P)_A \log (89/75)$$

$$K(P)_A = 18.8$$

Again as in Method 1 in correction SEL for power differences, the effects of velocity on the noise levels at different power settings must considered. Hence, normalize the 89% SEL down to the 75% pwr setting as follows:

$$L_{AE89\%} \text{ normalized to } {}_{75\%\ Vg = 156.3} = L_{AE}89\% + 7 \log \frac{170.5}{156.3}$$

$$= 87.8 + .26 = 88.1$$

Then we proceed to calculate a correction constant for SEL as before.

$$L_{AE} = L_{AE_{89\%norm}} - L_{AE_{75\%}} = K(P)_S \log\left(\frac{P1}{P2}\right)$$

$$88.1 - 85.9 = K(P)_S \log\left(\frac{89}{75}\right)$$

$$K(P)_S = 29.6$$

The resulting power correction equations are as follows:

$$L_{A_{FC}} = L_{A_{mc}} + K(P)_A \log\left[\frac{P1}{P_{REF}}\right]$$

$$L_{AE_{FC}} = L_{AE_{mc}} + K(P)_S \log\left[\frac{P1}{P_{REF}}\right]$$

where $P_1$ is the actual test power.

11.3 Results - Tables 11-1 and 11-2 show the derived relationships between AL (and SEL) and the base ten logarithm of the power ratios respectively for 7 of the 9 aircraft tested. The reference $M_H$ and power ratio are identified for each equation. In the case of the Cessna 170 and the Piper PA-38 (fixed pitch propeller) the power and $M_H$ vary simultaneously, thus a single relationship is adequate, reflecting both of these influences (see Section 10.0).

11.4 Discussion - In the case of $K(P)_A$ power correction constants, once again there is a wide range of values. The range 1.5 to 39.3 has a central tendency toward a value of 17. The method of deriving these values is acutely sensitive to the measured and corrected difference in sound levels between the two power settings. Thus a 0.6 dB change in the difference between noise levels for two different powers (i.e., 1.2 dB rather than 1.8 dB) can result in a difference in $K(P)_A$ of nearly 8 for a power ratio of (90/75):

$$22.7 = 1.8/\log(90/75)$$

$$15.2 = 1.2/\log(90/75)$$

Viewed within this experimental context, the variation in $K(P)_A$ is better understood.

While this analysis is by no means definitive, the selection of the average observed $K(P)_A$, = 17 is proposed as an interim factor to be used in adjusting for non-reference engine power. The constant is recommended as applicable to all engine/exhaust combinations.

TABLE 11-1

SUMMARY

AL VARIATION WITH BASE 10 LOGARITHM OF POWER RATIO

| AIRCRAFT | EQUATION | POWER RANGE % | $M_H$ |
|---|---|---|---|
| C-170 | - | - | - |
| PA-38 | - | - | - |
| PA-28 | $L_A = 3.2 \log (100/75)$ | 100-75 | .79 |
| | $L_A = 1.5 \log (75/75)$ | 75-55 | .735 |
| C-180 | $L_A = 12 \log (100/75)$ | 100-75 | .85 |
| | $L_A = 17 \log (75/50)$ | 75-50 | .78 |
| BARON 58P | $L_A = 1.79 \log (67/75)$ | 75-67 | .84 |
| | $L_A = 17.6 \log (75/50)$ | 75-50 | .84 |
| CESSNA 414 | $L_A = 18.8 \log (89/75)$ | 89-75 | .83 |
| | $L_A = 20.1 \log (75/50)$ | 75-52 | .72 |
| KING AIR 200 | $L_A = 17.4 \log (95/71)$ | 95-71 | .81 |
| | $L_A = 5.0 \log (71/47)$ | 71-47 | .78 |
| PA-42 | $L_A = 10.5 \log (100/75)$ | 100-75 | .77 |
| | $L_A = 17.4 \log (75/50)$ | 75-50 | .76 |
| CONQUEST I | $L_A = 39.3 \log (100/90)$ | 100-90 | .77 |
| | $L_A = 12.6 \log (90/75)$ | 90-75 | .76 |

TABLE 11-2

SUMMARY

SEL VARIATION WITH BASE 10 LOGARITHM OF POWER RATIO

| AIRCRAFT | EQUATION | POWER RANGE % | $M_H$ |
|---|---|---|---|
| C-170 | - | - | - |
| PA-38 | - | - | - |
| PA-28 | $L_{AE} = 1.6 \log (100/75)$<br>$L_{AE} = 9.9 \log (75/55)$ | 100-75<br>75-55 | .79<br>.735 |
| C-180 | $L_{AE} = 10.4 \log (100/75)$<br>$L_{AE} = 17 \log (75/50)$ | 100-75<br>75-50 | .85<br>.78 |
| BARON 58P | $L_{AE} = 13.4 \log (97/75)$<br>$L_{AE} = 11.4 \log (75/50)$ | 75-67<br>75-50 | .84<br>.84 |
| CESSNA 414 | $L_{AE} = 29.6 \log (89/75)$<br>$L_{AE} = 21.4 \log (75/52)$ | 89-75<br>75-52 | .83<br>.72 |
| KING AIR 200 | $L_{AE} = 16.9 \log (95/71)$<br>$L_{AE} = 5.6 \log (71/47)$ | 95-71<br>71-47 | .81<br>.78 |
| PA-42 | $L_{AE} = 30.7 \log (100/75)$<br>$L_{AE} = 12.2 \log (75/50)$ | 100-75<br>75-50 | .77<br>.76 |
| CONQUEST I | $L_{AE} = 30.6 \log (100/90)$<br>$L_{AE} = 13.9 \log (90/75)$ | 100-90<br>90-75 | .77<br>.76 |

12.0 Fully Corrected Takeoff Noise Data and a Description of the Correction Process - Fully corrected takeoff noise levels are presented in Table 12-1 for both SEL and ALM computed for the 18 GA aircraft participating in the aircraft noise measurement program. The 90 percent confidence interval is also displayed for each aircraft along with sample size. All noise levels have been corrected to account for nonreference altitude, velocity, Mach Number and power associated with actual takeoff operations.

12.1 The Need for Corrections - When noise measurement tests are conducted under conditions outside those specified as reference test conditions corrections are required to account for the resulting influence on the measured noise level.

12.2 Reference Test Conditions - The measured noise data obtained during the noise measurement tests conducted by the FAA in the summer and fall of 1982 were corrected to the following reference atmospheric conditions;

a. sea level atmospheric pressure of 1013.24 hPa (1013.25),

b. ambient air temperature of 15°C(ISA),

c. relative humidity of 70 percent; and

d. zero wind.

Note: The acoustic reference day conditions are the same as the airplane reference flight conditions except that the ambient air temperature shall be 25°C (ISA + 10°C).

12.3 Reference Test Parameters - In addition to these "primary" reference conditions it was necessary to compute three test parameter reference values, based on the reference atmospheric conditions.

## TABLE 12-1

## FULLY CORRECTED TAKEOFF NOISE LEVEL

| AIRCRAFT | MGTOW | $SEL_{fc}$ | 90% C.I. | N | $ALM_{fc}$ | 90% C.I. | N |
|---|---|---|---|---|---|---|---|
| C-180 | 2800 | 87.5 | 0.7 | 5 | 78.7 | .6 | 5 |
| C-170 | 2000 | 80.5 | 1.2 | 5 | 71.8 | 1.8 | 5 |
| PA-28 | 2900 | 82.6 | 0.7 | 10 | 76.5 | .9 | 10 |
| PA-38 | 1680 | 80.0 | 0.5 | 5 | 69.9 | 0.8 | 5 |
| KING AIR | 12,500 | 86.0 | 0.5 | 7 | 80.0 | .8 | 7 |
| PA-42 | 11,200 | 87.1 | 0.7 | 6 | 81.1 | .7 | 6 |
| C-414 | 6750 | 88.6 | 1.1 | 6 | 82.4 | 1.1 | 6 |
| B58-P | 6200 | 91.0 | .4 | 7 | 84.8 | .5 | 7 |
| C-210 | 3800 | 96.5 | 0.9 | 6 | 92.C | 1.1 | 6 |
| C-182 | 3100 | 80.4 | 1.1 | 6 | 72.4 | .2 | 6 |
| C-172 | 2300 | 83.0 | 0.3 | 6 | 74.1 | .5 | 6 |
| MERLIN | 14,500 | 85.3 | 0.3 | 6 | 80.6 | .5 | 6 |
| COMMANDER 900 | 10,700 | 79.3 | 0.5 | 6 | 70.9 | .6 | 6 |
| DUCHESS | 3900 | 91.6 | 0.4 | 7 | 84.5 | .5 | 7 |
| ARCHER | 2550 | 87.3 | 0.7 | 6 | 78.5 | .9 | 6 |
| BONANZA | 3400 | 93.2 | 0.3 | 7 | 87.3 | .5 | 6 |
| NAVAJO | 7000 | 94.1 | 0.3 | 7 | 87.9 | .5 | 7 |
| C-425 | 8200 | 80.7 | 0.6 | 7 | 72.7 | .5 | 7 |

1. Speed of Sound - The reference speed of sound (c) used to compute the reference Mach No. was computed using the formula $(T°F + 459.67)^{1/2} \times 49.02$. The reference temperature of 59°F yields the value for c of 1116.4 feet per second

2. Reference Helical Tip Mach Number - The reference helical tip Mach Number for each aircraft was computed using the specified propeller diameter and rpm along with the manufacturers specification of speed for best rate of climb (Vy) at sea level and at 59°F.

3. Reference Altitude - The reference altitude was computed for 8200 ft. (2500m) from brake release point (BRP) using the formula $(50 + (8200 - D_{50}) \times \tan \theta)$. The distance to reach 50 ft. in altitude ($D_{50}$) was obtained from the manufacturer's specification for each aircraft tested. In each case, the climb angle θ was computed using the reference value for Vy and best rate of climb specified in the pilot operating handbook.

12.4 Corrections Involving Deviations from Reference Altitude. Initially, it is helpful to define three terms intimately involved and sometimes confused in considering position deviations.

| | |
|---|---|
| Closest Point of Approach (CPA) : | The distance where a 90-degree angle exists between the aircraft flight path and a ray between the aircraft and the microphone. |
| Slant Range (SR): | The distance between the aircraft and the microphone at the time maximum noise level is recorded |
| Altitude (ALT) : | The distance between the aircraft and the microphone at the point where the aircraft is directly overhead (assuming no lateral deviation). |

For the test conducted in the FAA noise measurement program, the "as measured" noise values were corrected for spherical spreading, absorption and distance duration using altitude position data as opposed to CPA or Slant Range.

This procedure may be considered a "simplified" method. Prior to using this technique, a careful evaluation was conducted of previous FAA propeller driven aircraft noise tests. It was observed that the CPA, SR, and ALT distances were so close that, from a practicable standpoint, any one of the three could be used as shown in the following synopsis.

A similar trend was also noted in a French technical report abstracted below.

"Measured DeBruit Prodvit Par Les Avions Legers AV Decollage"

Rapport D'eTude No. 283.

This report compares slant range and altitude position correction using the following formulas:

a. $S_{21} = 20 \log H/H_{ref}$ where: H = altitude

b. $S_{22} = 20 \log AB/AB_{ref}$ where: AB = slant range

$S_{21} - S_{22}$ results in a mean average of 0.02 dB which suggests that there is no significant difference between the two methods.

Report AEE-80-26 "Noise Levels and Data Correction Analysis for Seven General Aviation Propeller Aircraft" - Tracking data were presented in this report in terms of the average "Acoustical Angle" or angle associated with the emission of ALM. Table 12-2 lists the aircraft tested, number of samples, and the mean and standard deviation of the acoustical angle. The distance from brake release is also provided. The individual mean acoustical angles range from 70° - 119° with an aggregate average of 88.1°. This translates to an average acoustical error of less than one tenth of a decibel.

TABLE 12-2

STATISTICAL ANALYSIS OF ACOUSTICAL ANGLE DATA

RPT. (REF. NO. 1) FAA-AEE-80-26, "NOISE LEVELS AND DATA CORRECTION ANALYSIS FOR SEVEN GENERAL AVIATION PROPELLER AIRCRAFT"

| A/C TYPE | NO. SAMPLES* | MEAN ACOUST ANG | S.D. ACOUST ANG | MIC LOCAT |
|---|---|---|---|---|
| PIPER PA36 375 | 12 | 86.4 | 4.5 | 3896M(12781') from BRP |
| PIPER PA31 325 | 2 | 94.9 | 0 | 3896M(12781') from BRP |
| | 8 | 97.4 | 8.8 | 5296M(17375') from BRP |
| | 2 | 93.8 | 0 | 5482M(19625') from BRP |
| CV 580 | 4 | 70.1 | 2.7 | 5115M(16781') from BRP |
| | 8 | 82.2 | 5.6 | 6515M(21375') from BRP |
| CESSNA 421C | 4 | 119 | 17.3 | 5296M(17375') from BRP |
| | 4 | 85.5 | 3.8 | 5982M(19625') from BRP |
| ROCKWELL 590B | 4 | 89 | 2.3 | 5982M(19625') from BRP |
| ROCKWELL 500S | 4 | 80.8 | 5.7 | 5296M(17375') from BRP |
| | 8 | 82 | 16.6 | 5982M(19625') from BRP |

*DEPARTURE EVENTS ONLY
**ANGLE OF ALM DURING OVERFLIGHT

12.5 Atmospheric Absorption and Spherical Spreading - In this report, takeoff noise data were corrected for the effects of absorption and spreading by using a simplified technique. The analysis presented in Section 8.0 shows that the simplified technique is a reasonable correction methodology. The simplified method consists of the formula $\Delta AL = 24 \log (ALT_T/ALT_R)$, which was derived from previous studies of noise propagation characteristics.

12.6 Mach Number Corrections - Level Flyover data were used to derive the Mach Number Correction constants $K(M)_S$ and $K(M)_A$ for SEL and AL respectively for use in the following equation $\Delta dB = K \log (M_{H(R)}/M_{H(T)})$. The methodologies used in deriving these formulas (see Table 10.1 and 10.3) are discussed in Section 11.2. The results suggest that in order for the correction to be accurate the formula should be derived for each aircraft under study.

12.7 Power Corrections - The as measured noise levels AL ($AL_{am}$) and SEL ($SEL_{am}$), require a power correction (P-Corr) to account for the differential influences which accompany aircraft power variations due to nonreference environmental and test flight procedures. The first step in computing this correction is to compute the test day power. The formula used to compute the test day power (%pwr) is given as follows:

$$\text{Percent Power} = \left[100 \times \sqrt{\frac{460 + 59°F}{460 + T°F}} - 2\%\right]$$

NOTE: The 2% is the power loss computed for the average altitude of 1000 ft AGL. This loss is not applicable to aircraft with a turboprop or a turbocharged engine.

The computed value is then substituted in the formula:

$$P\text{-}Corr = K(P)_A \log (100/\%Pwr)$$

$$P\text{-}Corr = K(P)_S \log (100/\%Pwr)$$

where: $K(P)_A$ and $K(P)_S$ are the constants derived from the formulas developed using level flyover data (see Table 11.1 and 11.2).

12.8 Distance - Duration Correction - The distance-duration correction accounts for the change in noise levels due to deviation of aircraft test altitude from reference altitude. The theoretical formula for this correction is $\Delta dB = 10 \log (ALT_R/ALT_T)$. However, after extensive analysis, it was observed that the empirical formula $\Delta dB = 7 \log (ALT_R/ALT_T)$ more accurately accounts for the effects of a change in duration with a change in distance as dis- d in Section 9.2. When this empirical formula is combined with the formula $\Delta dB = 24 \log (ALT_T/ALT_R)$ the equation $\Delta dB = 17 \log (ALT_T/ALT_R)$ is developed. This formula is used to correct the as-measured SEL value for spherical spreading, atmospheric absorption and distance-duration due to nonstandard environmental conditions and nonreference test flight procedures.

12.9 Velocity - Duration Correction - The theoretical equation utilized to correct for the difference in the test ground speed (Vg) and the speed for best rate of climb (Vy) is: $\Delta dB = 10 \log (Vg/Vy)$. However, the formula $\Delta dB = 7 \log (Vg/Vy)$ was used because the assumption was made that the same phenomena which govern a change in duration with a change in distance apply to a change in duration with a change in velocity. This concept is discussed in greater detail in Section 9.3.

12.10 Fully Corrected AL and SEL Equations - All the correction procedures discussed in previous sections are brought together to comprise the fully

corrected AL ($AL_{fc}$) equation.

$$L_{Afc} = L_{Aam} + 24 \log (ALT_R/ALT_T) + \text{Mach Corr} + \text{P-Corr}$$

The energy average metric SEL requires the same corrections as the intensity metric AL with the addition of (1) distance-duration and (2) velocity-duration corrections.

$$L_{AEfc} = L_{AEam} + 17 \log(ALT_R/ALT_T) + 7 \log(Vg/Vy) + \text{Mach Corr} + \text{P-Corr}$$

13.0 Correlation Between SEL and AL - The purpose of this analysis is to examine the correlation between the intensity metric AL and the energy dose metric SEL, using fully corrected takeoff noise levels.

13.1 Regression Analysis Results - A linear regression of SEL vs ALM was performed (see Figure 13.1) which provided a $R^2$ (coefficient of determination) of .96 for the following relation:

$$L_{AE} = .81 \times (L_{AM}) + 22.26$$

This provides the important capability (for test conditions with altitudes in the range of 4000 to 1600 ft and velocities in the range of 64 to 132 kts) to accurately estimate SEL from measured ALM noise level, and conversely ALM from measured SEL.

13.2 Discussion - Previous discussions within International Civil Aeronautical Organization indicated a preference for an energy-based noise evaluation measure for the proposed takeoff procedure, specifically the A-Weighted Sound Exposure Level, SEL. However, in light of the findings cited above it may be appropriate to consider use of maximum AL (ALM) which is a substantially simpler and more direct metric to acquire. Advantages of using the intensity (ALM) metric include:

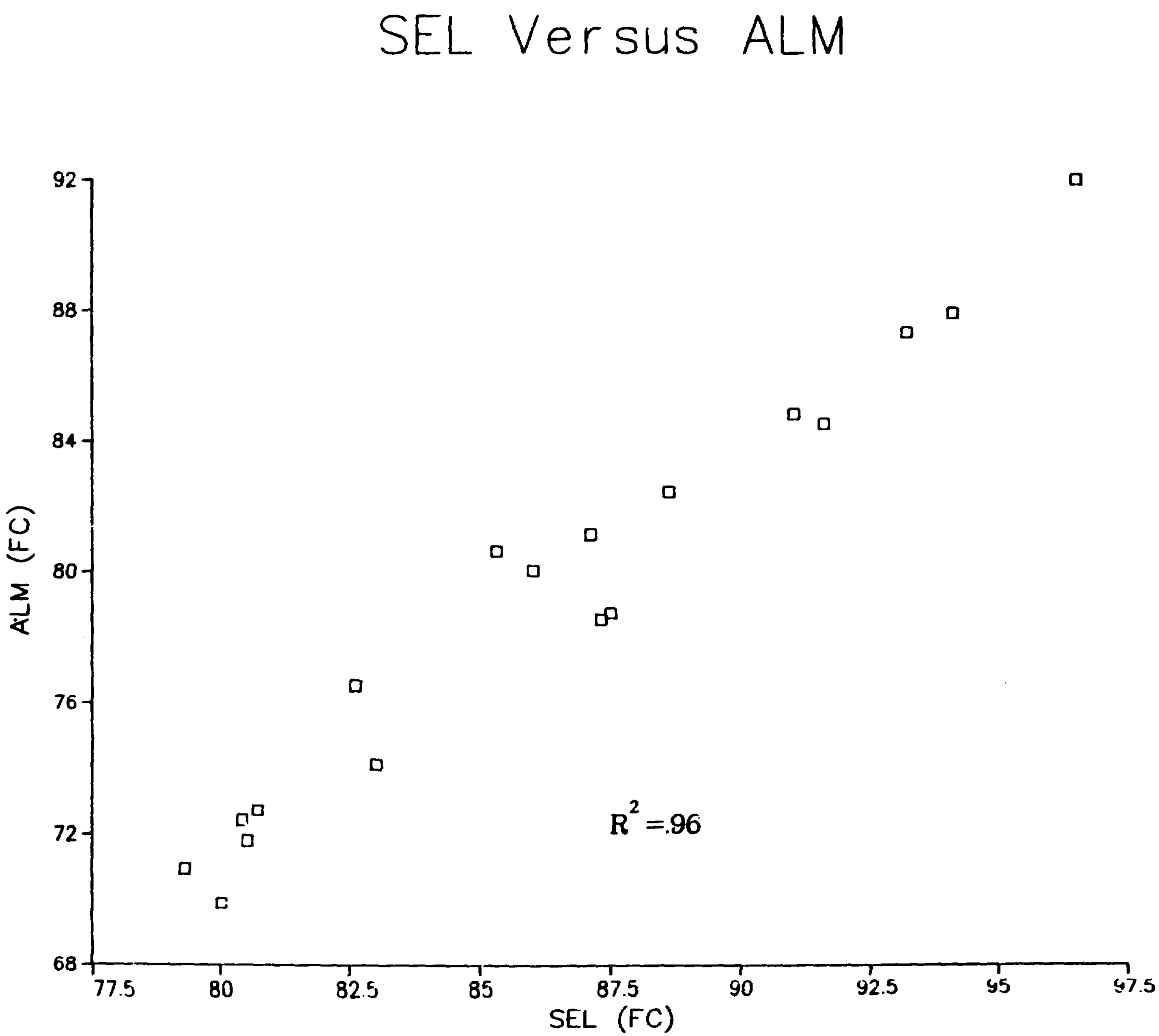
a. there is no need for tracking information, which is required to measure ground speed;

b. measurement instrumentation is far less sophisticated;

c. corrections for off-reference test conditions are simpler and less time-consuming; and

d. fewer corrections are required.

Inasmuch as the two noise evaluation measures are highly correlated, so that either can be confidently determined from the other, and the observed 90% confidence intervals for the measured values of ALM were somewhat less th   .ose for SEL in our tests (contrary to previous intuition), it is recommended that the A-weighted maximum sound level, ALM, be used as the noise evaluation measure for any new takeoff noise certification procedure.


SEL Versus ALM
92
88
84
80
76
72
68
ALM (FC)
77.5
80
82.5
85
87.5
90
92.5
95
97.5
SEL (FC)
$R^2 = .96$
FIGURE 13.1

14.0 Summary of Other Available Noise Level Data Acquired Using the Proposed Certification Takeoff Noise Test - This section provides a summary of results obtained from recent noise test programs conducted in Europe. British, German and French authorities were involved in assessing the proposed takeoff noise certification format. These data are presented here in order to expand the population of aircraft used in assessing the implications of the proposed revision. Table 14.1 presents pertinent information available from each report.

## REFERENCE TAKEOFF CONDITIONS

| AIRCRAFT | MGTOW (lbs) | $D_{50}$ (ft) | Vy(kts) | BRC(fpm) | CLIMB ANGLE | REFERENCE ALT (FT) | ALM | 90% C.I. | REF # |
|---|---|---|---|---|---|---|---|---|---|
| Sportavia-Putzer RF-5 | 1433.0 | 1712.6 | 59.4 | 590.5 | 5.6° | 364.2 | 74.5 | .38 | 5 |
| Robin DR 300-180 | 2204.6 | 1952.1 | 81.0 | 984.2 | 6.9° | 406.8 | 74.8 | .16 | 5 |
| Cessna 207A | 3800.7 | 1870.1 | 81.0 | 905.5 | 6.3° | 360.9 | 83.6 | .33 | 5 |
| Cessna 340 | 5974.5 | 2401.5 | 87.1 | 1496 | 10.5 | 397.0 | 83.1 | .57 | 5 |
| Beech 65 B90 | 9645.1 | 2260.5 | 109.1 | 1948.8 | 10.2 | 528.8 | 80.0 | .73 | 5 |
| R 2160 | 1763.1 | 1453.4 | 78.2 | 925.2 | 6.7 | 705.4 | 74.1 | .4 | 6 |
| HR 100-250 | 3086.4 | 2427.8 | 94.4 | 984.2 | 5.9 | 928.1 | 78.7 | .7 | 6 |
| C 310R | 5500.5 | 1837.2 | 106.8 | 1578.7 | 8.4 | 579.8 | 80.6 | .5 | 6 |
| 110ST | 1697.5 | 1345.1 | 75.5 | 629.9 | 4.7 | 825.1 | 71.2 | .5 | 6 |
| TB 10 | 2535.3 | 1778.2 | 72.8 | 750.0 | 5.8 | 651.6 | 75.6 | .6 | 6 |
| TB 20 | 2943.1 | 1673.2 | 91.7 | 1240.1 | 7.7 | 973.1 | 80.5 | .2 | 6 |
| Jet Stream | 14,550 | NA | 123.3 | NA | NA | NA | 72.3 | NA | 7 |
| Skyvan | 12,500 | NA | NA | NA | NA | NA | 82.3 | NA | 8 |
| Islander | 6600 | NA | NA | NA | NA | NA | 72.9 | NA | 9 |
| Firecracker | 2840 | 1230 | 104 | 1380 | 7.5 | NA | 70.9 | NA | 10 |

*NA - Not Available

TABLE 14.1

15.0 GA Regression Analysis - The purpose of this analysis is to determine if there exists a well defined relationship between aircraft noise levels, SEL and ALM, and the base 10 logarithm of gross weight.

To examine this hypothesis numerous linear and logarithmic regression analyses were performed for four different populations: 1) single engine pistons, 2) twin engine pistons, 3) twin engine turboprops and 4) all the aircraft tested.

Table 15-1 shows the results of this analysis for FAA data only. Figures15.1 and 15.2 provide scatter plots of the noise metrics SEL and ALM versus the logarithm of maximum gross takeoff weight (MGTOW) for the various aircraft types.

Table 15-2 shows the results of this analysis with each population increased using data (ALM only) available from French, German, and British sources, referenced 5, 7, 8, 9, and 10 respectively.

It is seen in Tables 15-1 and 15-2 that this hypothesis seems somewhat reliable for single engine piston aircraft, since Table 15-1 shows an $R^2$ (coefficient of determination) of 0.65 and 0.55 for the metrics ALM and SEL respectively, and Table 15-2 shows an $R^2$ of 0.47 for the increased single engine piston population for the metric ALM.

In viewing the results of this analysis for the remaining populations, twin engine pistons, twin engine turboprops and the grouped population, it is evident from the low values of $R^2$ (coefficient of determination) that there is very little correlation between the noise metrics ALM and SEL

and the base 10 logarithm of gross weight.

While a dependency is evident, it is clear that other factors such as propeller tip Mach Number and engine exhaust configuration play prominent roles in establishing noise levels. Nevertheless the concept of regulating noise level as a function of weight remains viable as a means for balancing increased productivity (weight) versus increased allowable noise level.

ALM VERSUS GROSS WEIGHT

REGRESSION ANALYSIS

FAA DATA

| | LINEAR | | | LOGARITHMIC | | |
|---|---|---|---|---|---|---|
| | SINGLE | TWIN | TWIN TURBO | SINGLE | TWIN | TWIN TURBO |
| SLOPE | 0.01 | $3.2x10^{-4}$ | 0.00 | 53.06 | 3.52 | 37.22 |
| INTERCEPT | 52.63 | 82.97 | 60.31 | -103.73 | 71.64 | -72.70 |
| $R^2$ | .71 | .04 | 0.49 | .65 | 0.03 | .49 |
| R | .84 | .20 | 0.70 | .81 | 0.18 | .70 |
| SAMPLE | 9 | 4 | 5 | 9 | 4 | 5 |

TABLE 15-1

REGRESSION ANALYSIS

ALM VERSUS GROSS WEIGHT

FAA, FRENCH, GERMAN, BRITISH

| | SINGLE | TWIN | TWIN TURBO | SINGLE | TWIN | TWIN TURBO |
|---|---|---|---|---|---|---|
| SLOPE | 0.01 | $-4.4x10^{-4}$ | $4.18x10^{-4}$ | 33.26 | -7.11 | 12.82 |
| INTERCEPT | 60.54 | 84.98 | 72.72 | -36.09 | 109.14 | 25.53 |
| $R^2$ | 0.55 | 0.03 | 0.04 | 0.47 | 0.03 | 0.05 |
| R | .74 | 0.16 | 0.20 | 0.69 | 0.10 | 0.23 |
| SAMPLE | 17 | 8 | 8 | 17 | 8 | 8 |

TABLE 15-2

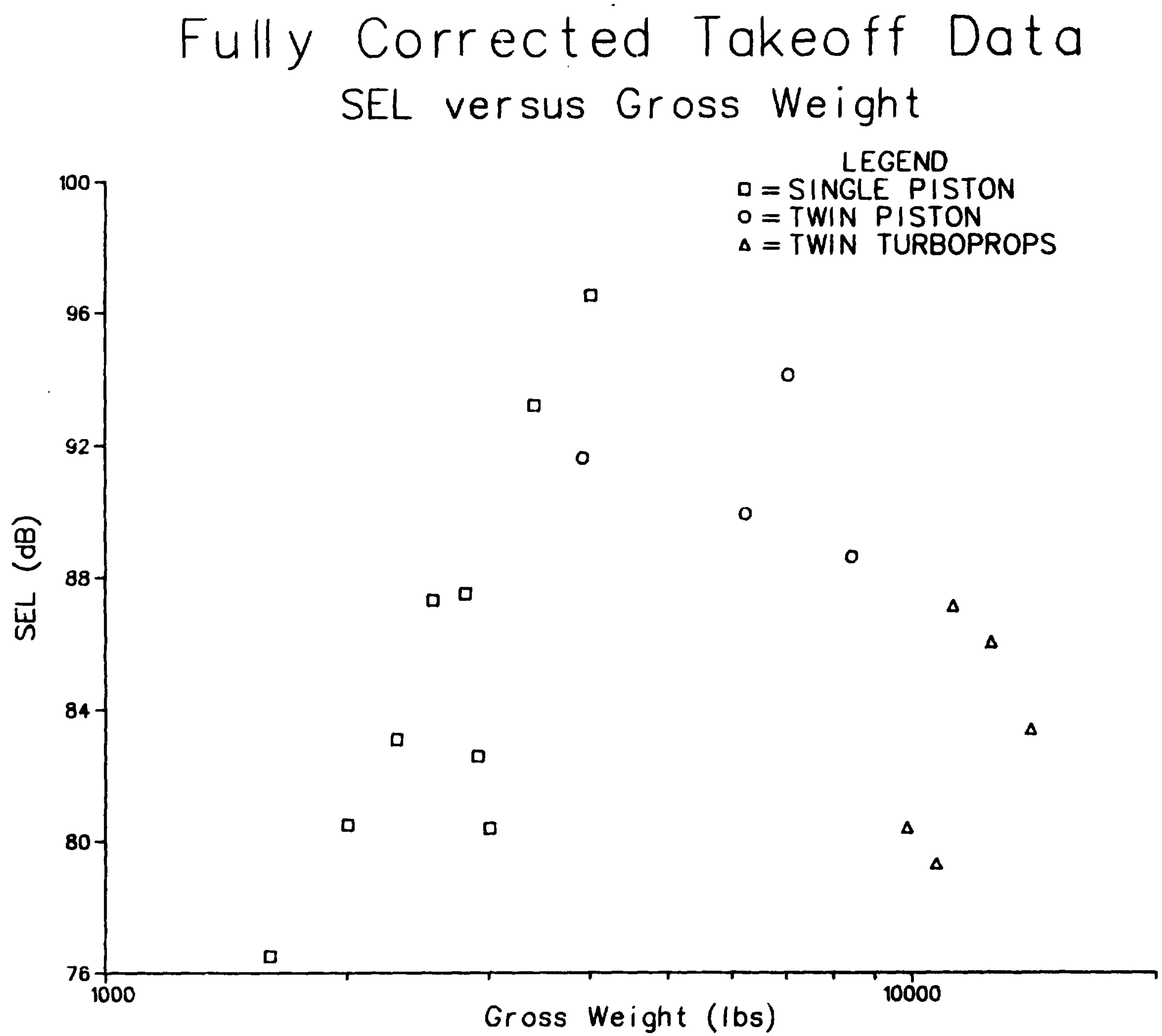

Fully Corrected Takeoff Data
SEL versus Gross Weight
LEGEND
□ = SINGLE PISTON
○ = TWIN PISTON
△ = TWIN TURBOPROPS
SEL (dB)
100
96
92
88
84
80
76
1000
10000
Gross Weight (lbs)

FIGURE 15.1

# Fully Corrected Takeoff Data

## ALM versus Gross Weight

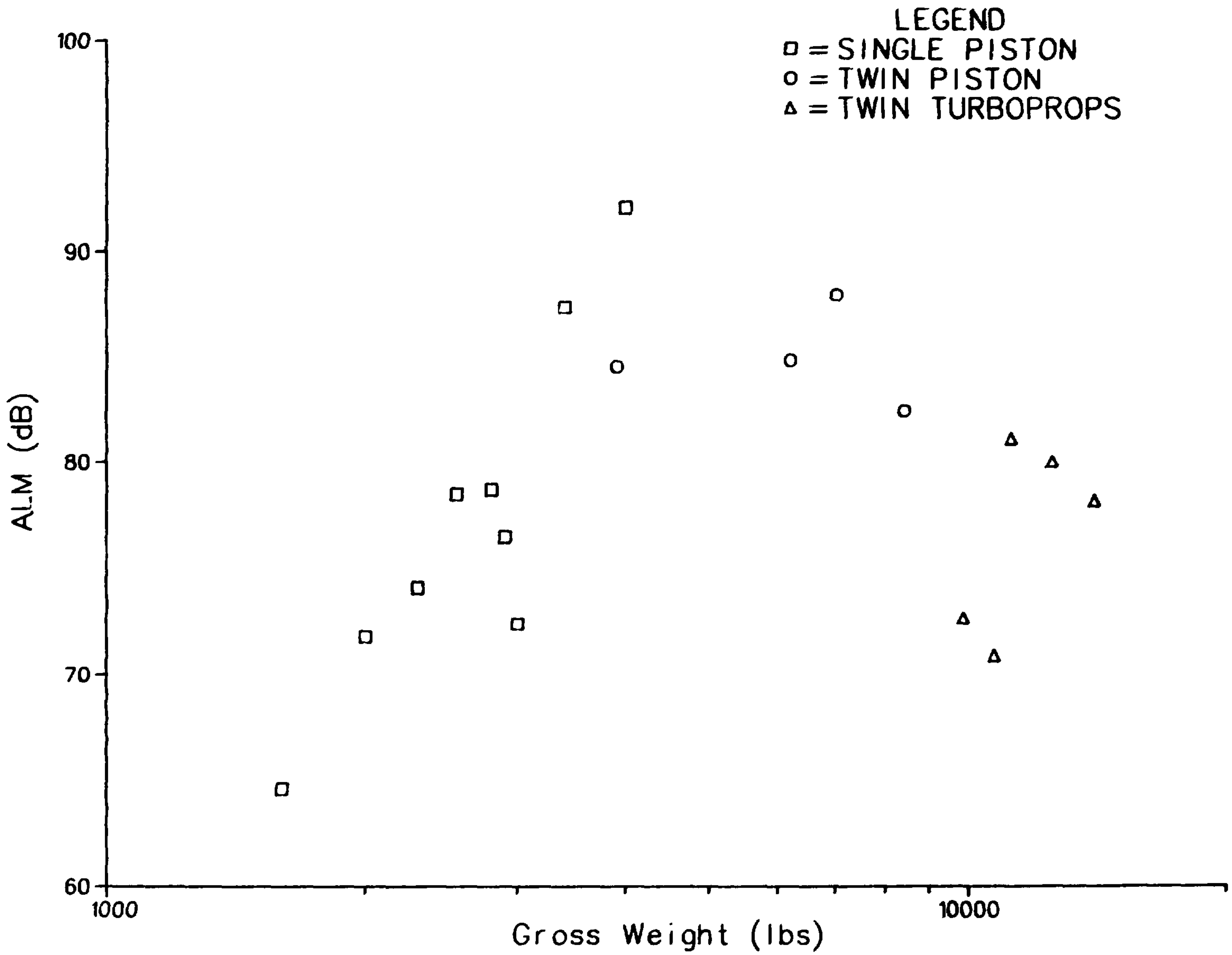



FIGURE 15.2

16.0 Equal Stringency Analysis - The purpose of this analysis is to examine how the rank-ordering of aircraft already certificated using FAR 36 Appendix F, would be affected if the proposed revision of ICAO Annex 16 is adopted using a takeoff procedure.

The first number indicates the rank ordering using takeoff ALM and the second number represents the rank ordering using their FAR 36 certificated ALM levels. As this figure shows, there would be some change in the ranking of aircraft. This difference is accounted for in part by the fact that the FAR 36 ALM levels were obtained using level flyover data corrected for takeoff performance, whereas the levels for the takeoff procedures were obtained for actual takeoff operations. The remaining differences likely reflect intrinsic differences between acoustical emission characteristics for the level flyover and takeoff flight regimes. The maximum change in pattern is seven places as exhibited by the King Air, and the average change in position is 2.3 for this population.

A linear and logarithmic regression analysis was performed for this population yielding equations of the formula:

Linear

$$\text{App F } L_{AM} = 0.47 \, (\text{Takeoff } L_{AM}) + 37.22$$

with $R^2$ (coefficient of determination) = .66 for a sample of 17 GA Aircraft.

Logarithmic

$$\text{App F } L_{AM} = 85.96 \log (\text{Takeoff } L_{AM}) - 88.97$$

with $R^2$ (coefficient of determination) = .66 for a sample of 17 GA Aircraft.

**Conclusions:** The relationship between FAR 36 Appendix F ALM versus takeoff ALM yields a respectable coefficient of determination $R^2$ of .66 for both linear and logarithmic regression analyses. This finding coupled with the fact that the average deviation in rank ordering is about 2 positions seems to suggest that certification using takeoff ALM noise levels would be roughly equivalent to certification using level flyover ALM corrected for performance.

# Level Flyover ALM versus Takeoff ALM

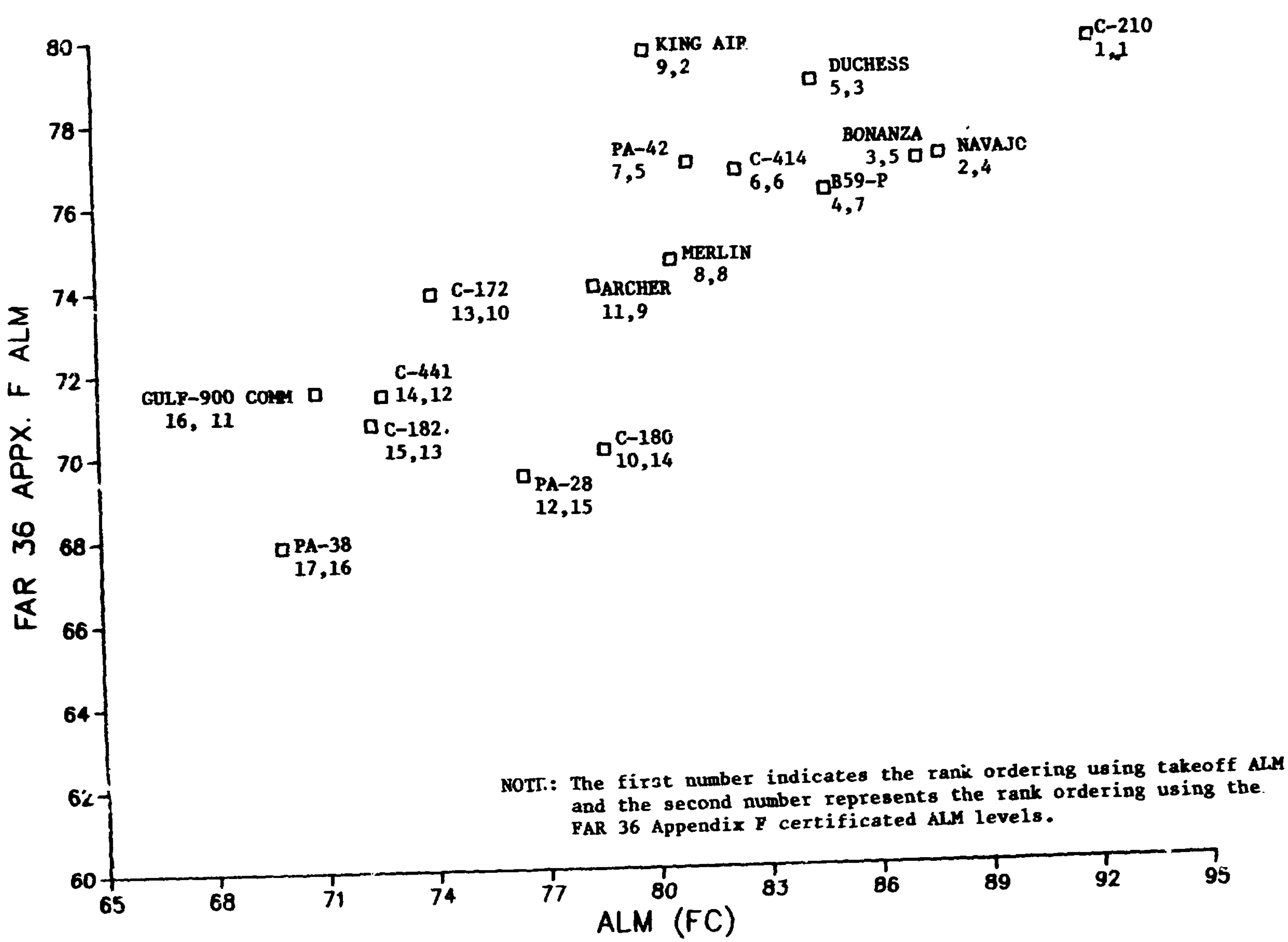



FIGURE 16.1

17.0 Noise Certification "Test Windows" - One of the objectives of the 1982 FAA General Aviation Noise Test program was to assess the impact of deviations from prescribed reference conditions. Another objective was to develop a logical structure of permissible deviations from reference test conditions, while quantifying the degree of confidence associated with any given correction procedure. The confidence one places in the correction procedure often plays a prominent role in defining boundaries of the "Test Window".

17.1 Deviations from Reference Flight Path - The subject of flight path deviations logically divides into separate discussions of vertical deviations and horizontal deviations.

17.1-2 Vertical Deviations - At the outset it is useful to review the probable causes associated with a vertical deviation from the reference takeoff flight path:

1. head wind (aloft)
2. non-standard day temperatures
3. non-reference weight
4. improper airspeed (not Vy)
5. high altitude testing

A second useful background tool is the concept of "correction ratio", defined herein as the ratio of the test altitude divided by the reference altitude. In Figure 17.1, the correction ratio is shown along the abscissa and corresponding decibel correction to ALM using the relationship $\Delta L_{AM}$ = 22 log (Corr. Ratio). Using this figure one can select any given allowable correction value in decibels and compute the allowable deviation above and below the reference altitude (note the asymmetry). While this particular figure has been developed for 22 log (Corr. Ratio), a similar graph can be made for any other propagation constant.

For the purpose of this discussion let us assume 1000' is the reference altitude ($ALT_{REF}$). For a 3 dB limit on the correction ratio we would allow a test window of 1368 feet to 730 feet, permitting 368 feet above or 270 feet below reference altitude.

Another useful perspective is gained by examining the performance of the 18 aircraft in the FAA 1982 test program. Table 17-1 shows that in many cases (12 of 18) the correction ratios lie within the nominal 3 dB ratio limits of 0.7 and 1.4. In a number of cases an unusually high correction ratio is observed, generally associated with winds aloft and/or light weight. From the data in Table I, it appears that, barring anomalous or incorrect testing conditions, a correction ratio window of 0.7 to 1.4 on vertical deviation is realistic and easily attainable.

The correction for non-standard altitude can be constrained (for reasons associated with the observed ability of pilots to perform), within the correction ratio range of 0.7 and 1.4. The limiting factor in this case does not appear to be the correction algorithm itself. In fact the 90% confidence interval on the use of K(A) = 21,

$$L_{AM} = K(A) \log ({}^{d}1/{}^{d}2)$$

is less than 0.5 dB.

17.1-2 Lateral Deviation - In the case of lateral deviation from reference ground track, one usually thinks in terms of degrees from zenith. In the case of a 1000-foot reference altitude we observe the following lateral deviations as a function of deviation angle(s):

FIGURE 17.1

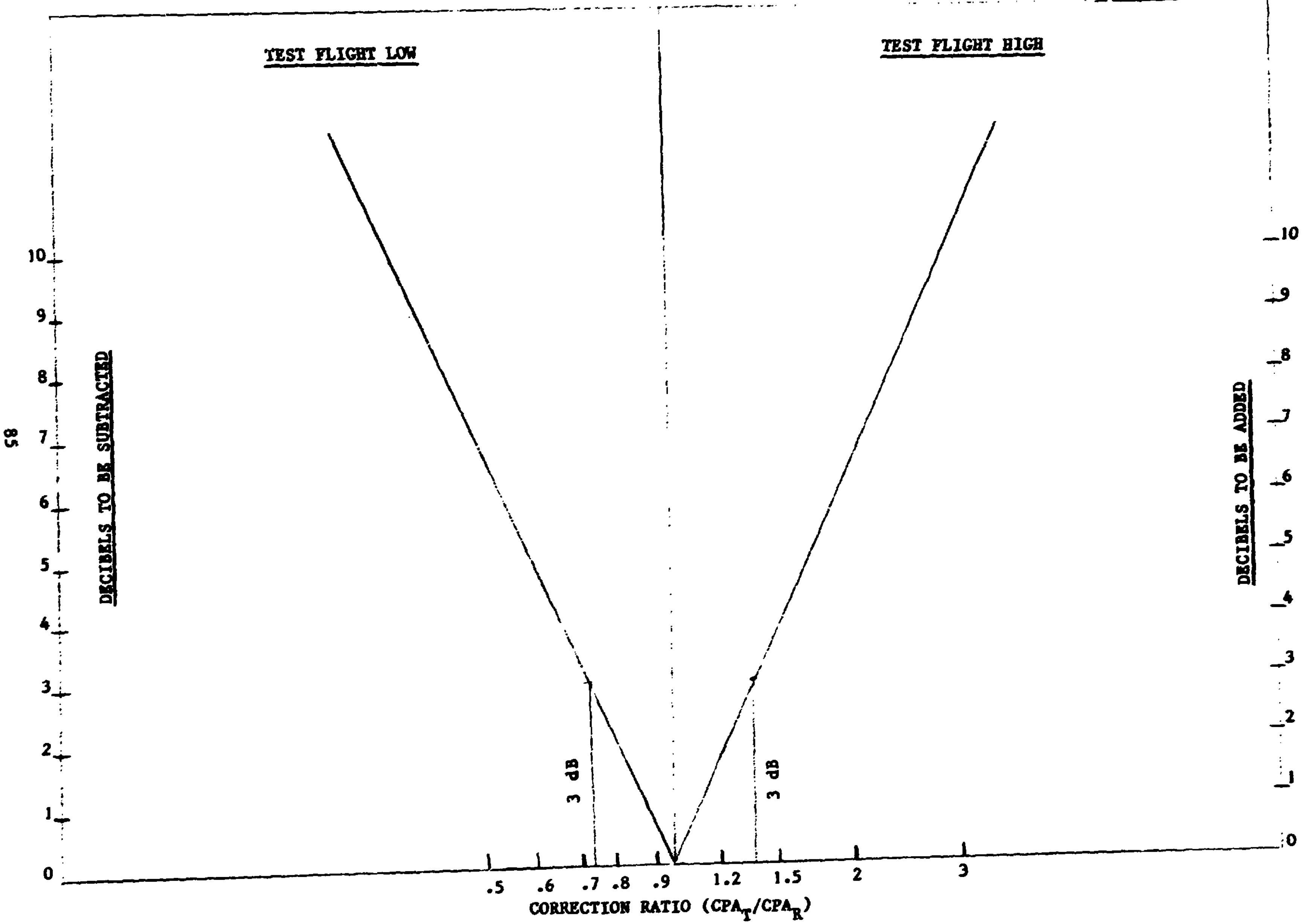

TEST FLIGHT LOW
TEST FLIGHT HIGH
DECIBELS TO BE SUBTRACTED
DECIBELS TO BE ADDED
0
1
2
3
4
5
6
7
8
9
10
3 dB
3 dB
.5
.6
.7
.8
.9
1.2
1.5
2
3
CORRECTION RATIO ($CPA_T/CPA_R$)

TABLE 17.1

T/O CORRECTION(s) ANALYSIS

| AIRCRAFT | N | $ALT_R$ | $ALT_T$ | $\Delta$ | $ALT_T/ALT_R$ | $22\log(ALT_T/ALT_R)$ | | | |
|---|---|---|---|---|---|---|---|---|---|
| C-180 | 5 | 1058' | 1582.6 | | 1.5 | 3.8 | | | |
| C-170 | 5 | 669' | 633.6 | | .9 | -0.5 | | | |
| PA-28 | 10 | 682' | 619.1 | | .9 | -0.9 | | | |
| PA-38 | 8 | 736' | 420.3 | | .6 | -5.4 | | | |
| KINGAIR 200 | 7 | 969' | 754.6 | | .8 | -2.1 | | | |
| PA-42 | 6 | 1052' | 587.5 | | .6 | -5.6 | | | |
| C-414 | 6 | 836' | 901.8 | | 1.1 | .7 | | | |
| B58-P | 7 | 759' | 521.5 | | .7 | -3.6 | | | |
| C-210 | 6 | 643' | 761.9 | | 1.2 | 1.6 | | | |
| C-182 | 6 | 827' | 835.2 | | 1.0 | .1 | | | |
| C-172 | 6 | 650' | 659.1 | | 1.0 | .1 | | | |
| MERLIN | 6 | 762' | 1136.9 | | 1.5 | 3.9 | | | |
| GULFSTREAM 900 | 6 | 1337' | 1543.9 | | 1.2 | 1.7 | | | |
| DUCHESS | 7 | 824' | 1421.1 | | 1.7 | 5.2 | | | |
| NAVAJO | 7 | 676' | 1343.6 | | 2.0 | 6.6 | | | |
| ARCHER | 6 | 658' | 1242.2 | | 1.9 | 6.1 | | | |
| BONANZA | 7 | 717' | 1180.4 | | 1.6 | 4.8 | | | |
| C-441 | 7 | 1085' | 1357.7 | | 1.3 | 2.1 | | | |

| Deviation Angle θ (Degrees) | Lateral Deviation (Tan θ x 1000), Feet |
|---|---|
| 5 | 88 |
| 10 | 176 |
| 15 | 268 |
| 20 | 364 |
| 25 | 466 |
| 30 | 577 |

As a practical matter it was reported by pilots participating in the test that maintaining the reference heading was difficult due to their inability to see the ground while in the climbout flight regime. Typically each pilot would make practice flights until receiving radio confirmation from ground observers verifying the proper flight track. The pilot would then fly that compass heading for subsequent takeoff events. After having found the right compass heading, pilots typically deviated no more than $\pm$10 degrees from the zenith.

In establishing a boundary on lateral deviation, it is necessary to consider the effects of exhaust shielding and source directivity. As these effects are largely unquantified and differ from one aircraft to the next, it is deemed inappropriate to allow any unnecessary latitude in this parameter. These concerns, coupled with the known ability to fly repeatedly within $\pm$10 degrees, leads one to the conclusion that 10 degrees be prescribed as the maximum allowable lateral deviation angle.

17.2 <u>Deviations from Reference Airspeed</u> - Maintaining the proper airspeed is one of the most important aspects of the test procedure. Improper airspeed generally results in both a velocity duration correction and the need for an altitude adjustment. The airspeed is a parameter totally within the control of the pilot and governed by visual resolution of the instrument reading. Adherence of pilots participating in the FAA test was, in every case, within 5 kts of the reference airspeed, (see Table 17-2).

In view of observed pilot performance, a limitation of $\pm 5$ kts is recommended as an appropriate test window.

TABLE 17.2

T/O CORRECTION ANALYSIS

VELOCITY CORRECTION

| AIRCRAFT | N | Vv(Kts) | $\bar{V}_{g}$(Kts) | $7\log \bar{V}_g/V_v$ | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| C-180 | 5 | 76 | 64.3 | -0.5 | | | | | |
| C-170 | 5 | 77.3 | 69.2 | -0.3 | | | | | |
| PA-28 | 10 | 97 | 89.8 | -0.2 | | | | | |
| PA-38 | 8 | 70 | 67.8 | -0.1 | | | | | |
| KINGAIR 200 | | 126 | | | | | | | *NOTE* no Vcorr used in T/O analysis ground speed missing |
| PA-42 | | 120 | | | | | | | *same as above i.e., $V_{corr}$ assumed = 0 |
| C-414 | 6 | 108 | 106.1 | -0.1 | | | | | |
| B58-P | 7 | 115 | 107.6 | -0.2 | | | | | |
| C-210 | 7 | 98 | 89.4 | -0.3 | | | | | |
| C-182 | 6 | 88.2 | 84.0 | -0.1 | | | | | |
| C-172 | 6 | 76 | 78.2 | 0.1 | | | | | |
| MERLIN | 6 | 147.5 | 132.5 | -0.3 | | | | | |
| GULFSTREAM 900 | 6 | 135.0 | 118.3 | -0.4 | | | | | |
| DUCHESS | | 97.5 | | | | | | | *Note no ground speed |
| NAVAJO | | 101.0 | | | | | | | same as above |
| ARCHER | | 76.0 | | | | | | | same as above — assume $V_{corr}$ = 0 |
| BONANZA | | 95.0 | | | | | | | same as above |
| C-441 | 7 | 115 | 91.4 | -0.7 | | | | | |

NOTE: N = Vg sample size

17.3 **Deviations from Reference Helical Tip Mach Number** - The test helical tip Mach number ($M_{H(T)}$) may be non-reference due to any of the following influences -

1. non-standard day temperature

2. improper air speed (very minor influence)

3. improper test RPM

First, consider temperature effects, probably the greatest potential cause of off-reference $M_H$. A few useful facts are provided below:

- Speed of Sound at 59°F = 1116 feet per second

  Speed of Sound at 95°F = 1154 feet per second

  Speed of Sound at 36°F = 1091 feet per second

- $M_H(95) = 0.967\ M_H(59)$, 3.3% above reference

- $M_H(36) = 1.023\ M_H(59)$, 2.3% below reference

- $\Delta = K \log \frac{M_{H(R)}}{M_{H(T)}}$ dB

- K is approximated as equal to 150

For a 36°F test day, one would need to subtract 3.2 dB from the measured data to arrive at a reference sound level, assuming $\Delta = 150 \log (M_{H(R)}/M_{H(T)})$. Conversely a value of 2.2 dB should be added to measured data on a 95°F day, using the same assumptions.

It is clear, that an arbitrary limit on the correction value in decibels will impose a restriction on the allowable test temperature window. This poses quite a predicament as the confidence associated with any generic correction function is generally very low. That is to say, a unique correction function appears necessary for each individual aircraft. This would, of course require a significantly greater amount of testing for each aircraft. In order to avoid or reduce the additional testing burden it may be feasible to establish the following scheme:

1. No limit on test temperature related $M_H$ corrections

2. If the test temperature is greater than 59°F then $\Delta = 150 \log M_{H(R)}/M_{H(T)}$ may be used to correct.

3. If the test temperature is less than 59°F then a separate, and independent correction function must be developed.

A comparison is shown in Table 17-3 between test and reference $M_H$ for the aircraft participating in the 1982 FAA test. It is observed that in most cases the $(M_{H(R)}/M_{H(T)})$ ratio is very close to 1.0. On the average there is less than a 1 percent error, primarily due to warmer than standard day temperatures.

TABLE 17.3

TAKEOFF CORRECTION ANALYSIS

MACH NO. CORRECTIONS

| AIRCRAFT | N | $M_{H_R}$ | $M_{H_T}$ | $M_{H(R)}/M_{H(T)}$ | $150 \log M_{H(R)}/M_{H(T)}$ | $171 \log M_{H(R)}/M_{H(T)}$ | | | |
|---|---|---|---|---|---|---|---|---|---|
| C-180 | 6 | .8271 | .813 | 1.0 | +1.1 | +0.1 | | | |
| C-170 | 8 | .715 | .702 | 1.0 | +1.2 | +0.1 | | | |
| PA-28 | 11 | .779 | .769 | 1.0 | +0.8 | +0.1 | | | |
| PA-38 | 8 | .670 | .658 | 1.C | +1.2 | +0.1 | | | |
| KINGAIR 200 | 7 | .793 | .789 | 1.0 | +0.3 | +0.1 | | | |
| PA-42 | 6 | .765 | .755 | 1.0 | +0.9 | +0.1 | | | |
| C-414 | 6 | .824 | .818 | 1.0 | +0.5 | +0.1 | | | |
| B58-P | 8 | .841 | .840 | 1.0 | +0.7 | +0.1 | | | |
| C-210 | 7 | .857 | .853 | 1.0 | +0.3 | +0.03 | | | |
| C-182 | 6 | .753 | .747 | 1.0 | +0.5 | +0.1 | | | |
| C-172 | 6 | .684 | .673 | 1.0 | +1.1 | +0.1 | | | |
| MERLIN | 6 | .696 | .670 | 1.0 | +2.5 | + .3 | | | |
| GULFSTREAM 900 | 6 | .690 | .692 | 1.0 | -0.2 | - .02 | | | |
| DUCHESS | 7 | .816 | .810 | 1.0 | +0.5 | + .05 | | | |
| NAVAJO | 8 | .820 | .808 | 1.0 | +1.0 | +0.1 | | | |
| ARCHER | 6 | .707 | .707 | 1.0 | 0 | 0 | | | |
| BONANZA | 7 | .857 | .851 | 1.0 | +0.5 | +0.1 | | | |
| C-441 | 7 | .715 | .723 | .99 | -0.7 | -0.1 | | | |

$M_{H(T)}$ = Average of the takeoff Mach numbers.

18.0 Evaluation of Aircraft Position Determination Systems - Three position determination systems were evaluated in the course of the measurement program. The first system was a 9.1 GHz primary radar unit which continuously tracked the test aircraft. The second system was a surveyers transit, set up perpendicular to the ground track at a distance of approximately 1500 feet opposite the microphone location. The third system involved a 35 millimeter SLR camera using slide film situated at the primary takeoff measurement location. While no great revelations were uncovered in comparing the three systems, a number of observations may be useful:

1. The photographic system using slide projections was remarkably accurate and easy to use.
2. Although the transit system is potentially prone to large operator error, with practice it constitutes an acceptable method for determining altitude. The transit operator also has the advantage of being able to calculate the altitude immediately.
3. The radar system, the only system capable of providing aircraft ground speed as one might expect, involves considerable expertise to operate and maintain.

Based on the above observations and the comparison of performance provided in Table 18-1 we arrive at the following recommendations:

1. The photographic system is recommended as the primary measurement tool. This recommendation is consistent with selection of the ALM metric which does not require consideration of ground speed corrections.
2. The transit method of position determination may be permitted, with certain cautions spelled out in regard to operator proficiency.

TABLE 13-1

MEASUREMENT SYSTEM COMPARISON

| | ADVANTAGES | DISADVANTAGES |
|---|---|---|
| TRANSIT | Inexpensive<br><br>Easily portable<br><br>Reasonable accuracy when used by a trained operator | Not capable of obtaining velocity and time data.<br><br>Prone to large error in the hands of a novice |
| RADAR SYSTEM | Capable of obtaining ground speed and complete flight path characteristics. Capable of generating REAL TIME position feed back data | Expensive, complex, requires lengthy learning process, requires external power supply, involved data reduction process including software development. |
| PHOTOGRAPHIC SYSTEM | Inexpensive, easily portable, accurate | Not capable of obtaining velocity data. |

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Appendix A: Takeoff Noise Data

This appendix contains as measured noise data along with other pertinent information used in arriving at fully corrected takeoff noise levels.

Abbreviations used in Appendix A

| | |
|---|---|
| RPM: | Propeller RPM (revolutions per minute) |
| $M_H$: | Helical Tip Mach Number |
| GS: | Ground Speed expressed in knots |
| $ALT_T$: | Observed Test Altitude (Above Ground Level) |
| $SEL_{am}$: | As measured Sound Exposure Level |
| $ALT_{corr}$: | Correction to reference altitude |
| $V_{corr}$: | Correction to reference Velocity |
| $M_{Hcorr}$: | Correction to reference Mach Number |
| $P_{corr}$: | Correction to reference Power |
| $SEL_{fc}$: | Fully corrected Sound Exposure Level |
| $AL_{am}$: | As Measured A-weighted Sound Level |
| $AL_{fc}$: | Fully Corrected A-weighted Sound Level |

# APPENDIX A

# TAKEOFF DATA

TABLE A-1

TAKEOFF DATA

AIRCRAFT C-180 SITE #1 TEST DATE 6-3-82

| A/C TEST DATA | | | | | SEL | | | | | | AL | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EVENT | RPM | $M_H$ | GS (KTS) | $ALT_T$ (FT) | $SEL_{am}$ | $ALT_{corr}$ | $V_{corr}$ | $M_{H\,corr}$ | $P_{corr}$ | $SEL_{fc}$ | $AL_{am}$ | $ALT_{corr}$ | $M_{H\,corr}$ | $P_{corr}$ | $AL_{fc}$ |
| 1 | 2550 | .813 | 68.6 | 1680.2 | 82.9 | 3.4 | -.3 | .6 | .2 | 86.8 | 72.5 | 4.9 | .9 | .3 | 78.6 |
| 2 | 2550 | .813 | 57.3 | 1432.7 | 84.9 | 2.2 | -.8 | .6 | .2 | 87.1 | 73.7 | 2.7 | .9 | .3 | 77.6 |
| 3 | 2550 | .813 | 63.0 | 1617.0 | 84.7 | 3.1 | -.6 | .6 | .2 | 88.0 | 73.5 | 4.2 | .9 | .3 | 78.9 |
| 5 | 2550 | .813 | 65.2 | 1664.1 | 84.9 | 3.3 | -.5 | .6 | .2 | 88.5 | 73.3 | 4.9 | .9 | .3 | 79.4 |
| 6 | 2550 | .813 | 67.4 | 1519.2 | 84.0 | 2.6 | -.4 | .6 | .2 | 87.0 | 74.2 | 3.5 | .9 | .3 | 78.9 |

*ALL UNITS EXPRESSED IN dB *ALL UNITS EXPRESSED IN dB

TABLE A-2

TAKEOFF DATA

AIRCRAFT C-170 SITE #2 TEST DATE 6-23-82

| A/C TEST DATA | | | | | SEL | | | | | | AL | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EVENT | RPM | $M_H$ | GS(KTS) | $ALT_T$(FT) | $SEL_{am}$ | $ALT_{corr}$ | $V_{corr}$ | $M_{H corr}$ | $P_{corr}$ | $SEL_{fc}$ | $AL_{am}$ | $ALT_{corr}$ | $M_{H corr}$ | $P_{corr}$ | $AL_{fc}$ |
| 1 | 2375 | .7022 | 71.2 | 536 | 80.7 | -1.6 | -.2 | .7 | - | 78.9 | 70.8 | -2.3 | .5 | N/A | 69.0 |
| 4 | 2375 | .7022 | 68.5 | 755 | 82.0 | .89 | -.4 | .7 | - | 82.5 | 70.9 | 1.3 | .5 | N/A | 74.3 |
| 5 | 2375 | .7022 | 67.6 | 641 | 81.0 | -.32 | -.4 | .7 | - | 80.3 | 71.4 | -.4 | .5 | N/A | 71.5 |
| 7 | 2375 | .7022 | 66.2 | 623 | 81.6 | -.5 | -.5 | .7 | - | 80.6 | 72.5 | -.8 | .5 | N/A | 72.2 |
| 8 | 2375 | .7032 | 72.5 | 613 | 81.2 | -.6 | -.2 | .6 | - | 80.4 | 72.4 | -.9 | .5 | N/A | 72.0 |

TABLE A-3

TAKEOFF DATA

AIRCRAFT PA-28 Turbo Arrow IV SITE #[illegible] TEST DATE 7-13-82

| A/C TEST DATA | | | | | SEL | | | | | | AL | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EVENT | RPM | $M_H$ | GS(KTS) | $ALT_{T(FT)}$ | $SEL_{am}$ | $ALT_{corr}$ | $V_{corr}$ | $M_{H corr}$ | $P_{corr}$ | $SEL_{fc}$ | $AL_{am}$ | $ALT_{corr}$ | $M_{H corr}$ | $P_{corr}$ | $AL_{fc}$ |
| 1 | 2575 | .7714 | 87.6 | 768.6 | 82.2 | .9 | -.3 | .5 | .01 | 83.4 | 76.0 | 1.2 | .6 | 0 | 77.8 |
| 2 | 2575 | .7714 | 88.9 | 702.8 | 83.0 | .2 | -.3 | .5 | .01 | 83.5 | 77.0 | .3 | .6 | 0 | 77.9 |
| 3 | 2575 | .7714 | 89.9 | 738.2 | 81.1 | .6 | -.2 | .5 | .01 | 82.1 | 75.1 | .8 | .6 | 0 | 76.5 |
| 4 | 2575 | .7714 | 85.5 | 614.1 | 83.0 | -.8 | -.4 | .5 | .01 | 82.4 | 77.2 | -1.1 | .6 | 0 | 76.7 |
| 5 | 2450 | .7714 | 86.8 | 587.8 | 79.9 | -.3 | -.3 | .5 | .01 | 79.1 | 72.7 | -1.5 | .6 | 0 | 71.8 |
| 7 | 2575 | .7714 | 89.0 | 651.6 | 83.1 | -.5 | -.3 | .5 | .01 | 83.1 | 76.9 | -.5 | .6 | 0 | 77.0 |
| 14 | 2575 | .7661 | 92.1 | 527.6 | 84.4 | -1.9 | -.2 | .8 | .02 | 8[illegible].2 | 78.5 | -2.7 | 1.0 | 0 | 76.8 |
| 15 | 2575 | .7661 | 92.6 | 547.3 | 84.0 | -1.6 | -.1 | .8 | .02 | 83.2 | 78.2 | -2.3 | 1.0 | 0 | 76.9 |
| 16 | 2575 | .7661 | 93.7 | 508.0 | 84.3 | -2.2 | -.1 | .8 | .02 | 83.0 | 78.4 | -3.1 | 1.0 | 0 | 76.3 |
| 17 | 2575 | .7661 | 91.6 | 545 | 84.0 | -1.6 | -.2 | .8 | .02 | 83.1 | 78.3 | -2.3 | 1.0 | 0 | 77.0 |

TABLE A-4

TAKEOFF DATA

AIRCRAFT PA-38 TOMOHAWK　　SITE #2　　TEST DATE 8-10-82

| A/C TEST DATA | | | | | SEL | | | | | | AL | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EVENT | RPM | $H_H$ | GS (KTS) | $ALT_T$ (FT) | $SEL_{am}$ | $ALT_{corr}$ | $V_{corr}$ | $H_{H corr}$ | $P_{corr}$ | $SEL_{fc}$ | $AL_{am}$ | $ALT_{corr}$ | $H_{H corr}$ | $P_{corr}$ | $AL_{fc}$ |
| 1 | 2350 | .6584 | 72.3 | – | 79.3 | – | .1 | .5 | 0 | – | 69.4 | – | .6 | 0 | |
| 2 | 2350 | .6584 | 70.8 | 680.4 | 80.4 | -0.6 | .03 | .5 | 0 | 80.3 | 70.2 | -0.9 | .6 | 0 | 69.9 |
| 3 | 2350 | .6584 | 66.9 | – | 80.6 | – | -.1 | .5 | 0 | – | 70.3 | – | .6 | 0 | |
| 4 | 2350 | .6584 | 67.1 | – | 81.1 | – | -.1 | .5 | 0 | – | 70.4 | – | .6 | 0 | |
| 5 | 2350 | .6584 | 72.2 | 707.9 | 80.1 | -0.3 | .1 | .5 | 0 | 80.4 | 70.0 | -0.4 | .6 | 0 | 70.2 |
| 6 | 2350 | .6584 | 64.0 | 674.0 | 80.0 | -0.7 | -.3 | .5 | 0 | 79.5 | 69.9 | -1.0 | .6 | 0 | 69.5 |
| 7 | 2350 | .6584 | 63.0 | 787.2 | 79.7 | 0.5 | -.3 | .5 | 0 | 80.4 | 70.0 | 0.7 | .6 | 0 | 71.3 |
| 8 | 2350 | .6584 | 66.4 | 680.4 | 79.8 | -0.6 | -.2 | .5 | 0 | 79.5 | 69.2 | -0.9 | .6 | 0 | 68.8 |

TABLE A-5

TAKEOFF DATA

AIRCRAFT KING AIR 200 SITE #2 TEST DATE 8-31-82

| A/C TEST DATA | | | | | SEL | | | | | | AL | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EVENT | RPM | $M_H$ | GS(KTS) | $ALT_T$(FT) | $SEL_{am}$ | $ALT_{corr}$ | $V_{corr}$ | $M_{H_{corr}}$ | $P_{corr}$ | $SEL_{fc}$ | $AL_{am}$ | $ALT_{corr}$ | $M_{H_{corr}}$ | $P_{corr}$ | $AL_{fc}$ |
| 1 | 2000 | .7894 | N/A | 656 | 89.8 | -4.2 | 0 | .1 | .1 | 85.8 | 85.3 | -5.8 | .1 | .1 | 79.7 |
| 2 | 2000 | .7894 | N/A | 665 | 90.0 | -4.0 | 0 | .1 | .1 | 86.2 | 86.0 | -5.7 | .1 | .1 | 80.5 |
| 3 | 2000 | .7894 | N/A | 693 | 88.8 | -3.7 | 0 | .1 | .1 | 85.3 | 84.3 | -5.2 | .1 | .1 | 79.3 |
| 4 | 2000 | .7894 | N/A | 766 | 88.4 | -2.9 | 0 | .1 | .1 | 85.7 | 83.9 | -4.2 | .1 | .1 | 79.9 |
| 5 | 2000 | .7894 | N/A | 847 | 89.4 | -2.2 | 0 | .1 | .1 | 87.4 | 85.1 | -3.2 | .1 | .1 | 82.1 |
| 6 | 2000 | .7894 | N/A | 893 | 87.5 | -1.8 | 0 | .1 | .1 | 85.9 | 81.7 | -2.6 | .1 | .1 | 79.3 |
| 7 | 2000 | .7894 | N/A | 762 | 88.4 | -3.1 | 0 | .1 | .1 | 85.5 | 83.2 | -4.3 | .1 | .1 | 79.1 |
| | | | | | | | | | | | | | | | |
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TABLE A-6

TAKEOFF DATA

AIRCRAFT PA-42 CHEYENNE SITE #2 TEST DATE 9-8-82

| A/C TEST DATA | | | | | SEL | | | | | | AL | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EVENT | RPM | $M_H$ | GS(KTS) | $ALT_T$(FT) | $SEL_{am}$ | $ALT_{corr}$ | $V_{corr}$ | $M_{H_{corr}}$ | $P_{corr}$ | $SEL_{fc}$ | $AL_{am}$ | $ALT_{corr}$ | $M_{H_{corr}}$ | $P_{corr}$ | $AL_{fc}$ |
| 22 | 2000 | .7546 | 115 | 1140 | 85.4 | 0.6 | 0 | .3 | .3 | 86.6 | 78.4 | .9 | .4 | .1 | 79.8 |
| 23 | 2000 | .7546 | 115 | 1293 | 85.3 | 1.5 | 0 | .3 | .3 | 87.4 | 78.4 | 2.1 | .4 | .1 | 81.0 |
| 24 | 2000 | .7546 | 115 | 1154 | 85.7 | 0.7 | 0 | .3 | .3 | 87.0 | 79.3 | 1.0 | .4 | .1 | 80.8 |
| 25 | 2000 | .7546 | 115 | 1337 | 86.1 | 1.8 | 0 | .3 | .3 | 88.5 | 79.2 | 2.5 | .4 | .1 | 82.2 |
| 26 | 2000 | .7546 | 115 | 997 | 85.8 | -.4 | 0 | .3 | .3 | 86.0 | 81.3 | -.6 | .4 | .1 | 81.2 |
| 27 | 2000 | .7546 | 115 | 1232 | 85.4 | 1.2 | 0 | .3 | .3 | 87.2 | 79.7 | 1.6 | .4 | .1 | 81.8 |

TABLE A-7

TAKEOFF DATA

AIRCRAFT C-414 CHANCELLOR SITE #1 TEST DATE 9-14-82

| A/C TEST DATA | | | | | SEL | | | | | | AL | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EVENT | RPM | $M_H$ | GS(KTS) | $ALT_T$(FT) | $SEL_{am}$ | $ALT_{corr}$ | $V_{corr}$ | $M_{H\,corr}$ | $P_{corr}$ | $SEL_{fc}$ | $AL_{am}$ | $ALT_{corr}$ | $M_{H\,corr}$ | $P_{corr}$ | $AL_{fc}$ |
| 23 | 2700 | .8179 | 108.3 | 833.2 | 89.3 | .5 | .01 | .4 | .3 | 90.5 | 82.7 | .7 | .4 | .2 | 84.0 |
| 24 | 2700 | .8179 | 104.2 | 876.2 | 87.5 | .4 | -.1 | .4 | .3 | 88.5 | 81.4 | .5 | .4 | .2 | 82.5 |
| 25 | 2700 | .8195 | 107.1 | 825.2 | 85.9 | -.1 | -.02 | .3 | .3 | 86.4 | 79.4 | -.1 | .3 | .2 | 79.8 |
| 26 | 2700 | .8179 | 108.0 | 902.4 | 87.2 | .6 | 0 | .4 | .3 | 88.5 | 81.1 | .8 | .4 | .2 | 82.5 |
| 27 | 2700 | .8185 | 104.9 | 938.7 | 87.4 | .3 | -.09 | .3 | .3 | 88.7 | 81.2 | 1.2 | .4 | .2 | 83.0 |
| 28 | 2700 | .8179 | 104.2 | 975.1 | 87.4 | 1.2 | -.1 | .4 | .3 | 89.2 | 80.2 | 1.6 | .4 | .2 | 82.4 |

TABLE A-8

TAKEOFF DATA

AIRCRAFT B-58P BARON　　　SITE #2　　　TEST DATE 9-28-82

| A/C TEST DATA | | | | | SEL | | | | | | AL | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EVENT | RPM | $M_H$ | GS (KTS) | $ALT_T$ (FT) | $SEL_{am}$ | $ALT_{corr}$ | $V_{corr}$ | $M_{H_{corr}}$ | $P_{corr}$ | $SEL_{fc}$ | $AL_{am}$ | $ALT_{corr}$ | $M_{H_{corr}}$ | $P_{corr}$ | $AL_{fc}$ |
| 2 | 2700 | .8404 | 105.2 | 496.2 | 93.9 | -3.2 | -.3 | 0 | 0 | 90.4 | 88.4 | -4.5 | .1 | 0 | 84.0 |
| 3 | 2700 | .8398 | 106.1 | 566.8 | 93.6 | -2.1 | - .3 | 0 | 0 | 91.2 | 87.6 | -3.0 | .1 | 0 | 84.7 |
| 4 | 2700 | .8404 | 113.4 | 435.8 | 94.1 | -4.1 | -.03 | .1 | 0 | 90.1 | 89.4 | -5.8 | .1 | 0 | 83.7 |
| 5 | 2700 | .8404 | 109.1 | 456.3 | 95.4 | -3.8 | -.1 | 0 | 0 | 91.5 | 90.5 | -5.3 | .1 | 0 | 85.3 |
| 6 | 2700 | .8404 | 112.2 | 513.2 | 94.4 | -2.8 | -.1 | 0 | 0 | 91.5 | 89.7 | -4.0 | .1 | 0 | 85.8 |
| 7 | 2700 | .8404 | 100.0 | 620.1 | 93.3 | -1.5 | -.4 | 0 | 0 | 91.4 | 87.1 | -2.1 | .1 | 0 | 85.1 |
| 8 | 2700 | .8404 | 107.2 | 561.8 | 93.2 | -2.2 | -.2 | 0 | 0 | 90.8 | 88.1 | -3.1 | .1 | 0 | 85.1 |

*NOTE: ACTUAL PROPELLER SPEED = 182 PLUS INDICATED VALUE

TABLE A-9

TAKEOFF DATA

AIRCRAFT C-210 CENTURION    SITE #1    TEST DATE 10-5-82

| A/C TEST DATA | | | | | SEL | | | | | | AL | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EVENT | RPM* | $R_H$ | GS(KTS) | $ALT_{T}$(FT) | $SEL_{am}$ | $ALT_{corr}$ | $V_{corr}$ | $R_{H corr}$ | $P_{corr}$ | $SEL_{fc}$ | $AL_{am}$ | $ALT_{corr}$ | $R_{H corr}$ | $P_{corr}$ | $AL_{fc}$ |
| 1 | 2700 | .8538 | 89.9 | 814.7 | 93.1 | 1.9 | -.3 | .1 | .1 | 94.9 | 86.9 | 2.4 | .2 | .1 | 89.6 |
| 2 | 2700 | .8530 | - | - | 94.5 | 2.5 | 0 | .2 | .1 | - | 88.3 | 3.8 | .3 | .1 | 92.5 |
| 3 | 2700 | .8530 | 87.3 | 789.3 | 94.3 | 1.3 | -.3 | .2 | .1 | 95.6 | 88.2 | 2.1 | .3 | .1 | 90.6 |
| 4 | 2700 | .8536 | 87.3 | 812 | 95.4 | 1.7 | -.3 | .2 | .1 | 97.1 | 90.1 | 2.4 | .2 | .1 | 92.8 |
| 5 | 2700 | .8538 | 92.4 | 993.8 | 94.6 | 3.2 | -.2 | .1 | .1 | 97.8 | 89.3 | 4.5 | .2 | .1 | 94.1 |
| 6 | 2700 | .8536 | 91.4 | 983.2 | 94.2 | 3.1 | -.2 | .2 | .1 | 97.4 | 88.4 | 4.4 | .2 | .1 | 93.1 |
| 7 | 2700 | .8536 | 87.9 | 978.2 | 93.2 | 3.1 | -.3 | .2 | .1 | 96.3 | 86.9 | 4.3 | .2 | .1 | 91.5 |

TABLE A-10

TAKEOFF DATA

AIRCRAFT C-182 SKYLANE SITE #1 TEST DATE 10-5-82

| A/C TEST DATA | | | | | SEL | | | | | | AL | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EVENT | RPM | $H_H$ | GS(KTS) | $ALT_T$(FT) | $SEL_{as}$ | $ALT_{corr}$ | $V_{corr}$ | $H_{H corr}$ | $P_{corr}$ | $SEL_{fc}$ | $AL_{am}$ | $ALT_{corr}$ | $H_{H corr}$ | $P_{corr}$ | $AL_{fc}$ |
| 14 | 2400 | .7476 | 94.3 | 735 | 77.9 | -1.2 | .5 | .3 | .1 | 77.6 | 73.6 | -1.7 | .4 | .1 | 72.4 |
| 15 | 2400 | .7476 | 80.4 | 928 | 80.4 | .4 | .05 | .3 | .1 | 81.2 | 71.7 | .5 | .4 | .1 | 72.7 |
| 16 | 2400 | .7472 | 82.2 | 953 | 80.0 | .5 | .12 | .3 | .1 | 81.0 | 71.3 | .7 | .4 | .1 | 72.5 |
| 17 | 2400 | .7470 | 83.2 | 895 | 80.2 | .1 | .16 | .3 | .1 | 80.9 | 71.4 | .2 | .5 | .1 | 72.2 |
| 18 | 2400 | .7467 | 78.1 | 873 | 80.2 | .2 | -.03 | .3 | .1 | 80.8 | 71.8 | .3 | .5 | .1 | 72.7 |
| 19 | 2400 | .7470 | 85.5 | 883 | 80.0 | .4 | .2 | .3 | .1 | 81.0 | 70.9 | .5 | .5 | .1 | 72.0 |

TABLE A-11

TAKEOFF DATA

AIRCRAFT C-172 SKYHAWK    SITE #1    TEST DATE 10-5-82

| A/C TEST DATA | | | | | SEL | | | | | | AL | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EVENT | RPM | $M_H$ | GS(KTS) | $ALT_T$(FT) | $SEL_{am}$ | $ALT_{corr}$ | $V_{corr}$ | $M_{H corr}$ | $P_{corr}$ | $SEL_{fc}$ | $AL_{am}$ | $ALT_{corr}$ | $M_{H corr}$ | $P_{corr}$ | $AL_{fc}$ |
| 26 | 2300 | .6728 | 78.5 | 677 | 82.0 | .07 | .1 | .4 | 0 | 82.6 | 73.1 | .1 | .5 | 0 | 73.7 |
| 27 | 2300 | .6728 | 78.0 | 724 | 82.5 | .3 | .08 | .4 | 0 | 83.3 | 73.6 | .4 | .5 | 0 | 74.5 |
| 28 | 2300 | .6728 | 77.8 | 700 | 82.7 | .1 | .07 | .4 | 0 | 83.3 | 74.3 | .2 | .5 | 0 | 75.0 |
| 29 | 2300 | .6728 | 81.4 | 635 | 82.9 | -.5 | .2 | .4 | 0 | 83.0 | 74.6 | -.8 | .5 | 0 | 74.3 |
| 30 | 2300 | .6728 | 78.8 | 745 | 81.9 | .1 | .1 | .4 | 0 | 82.6 | 72.5 | .3 | .5 | 0 | 73.2 |
| 31 | 2300 | .6728 | 74.7 | 724 | 82.4 | .4 | -.05 | .4 | 0 | 83.1 | 72.9 | .6 | .5 | 0 | 74.0 |

TABLE A-12

TAKEOFF DATA

AIRCRAFT MERLIN 227-AT SITE #1 TEST DATE 10-19-82

| A/C TEST DATA | | | | | SEL | | | | | | AL | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EVENT | RPM | $M_H$ | GS(KTS) | $ALT_T$(FT) | $SEL_{sm}$ | $ALT_{corr}$ | $V_{corr}$ | $M_{H_{corr}}$ | $P_{corr}$ | $SEL_{fc}$ | $AL_{sm}$ | $ALT_{corr}$ | $M_{H_{corr}}$ | $P_{corr}$ | $AL_{fc}$ |
| 2 | 1591 | .6998 | 129.9 | 1113.6 | 83.6 | 2.9 | -.4 | -.1 | -.1 | 85.9 | 77.0 | 4.1 | -.1 | -.1 | 80.9 |
| 3 | 1591 | .6998 | 134.6 | 1124.3 | 82.9 | 3.0 | -.3 | -.1 | -.1 | 85.4 | 76.7 | 4.2 | -.1 | -.1 | 80.7 |
| 4 | 1591 | .6998 | 134.7 | 1098.9 | 82.7 | 2.8 | -.3 | -.1 | -.1 | 85.0 | 77.2 | 3.9 | -.1 | -.1 | 80.7 |
| 5 | 1591 | .6998 | 136.4 | 1127.9 | 82.8 | 3.0 | -.2 | -.1 | -.1 | 85.4 | 76.7 | 4.2 | -.1 | -.1 | 80.7 |
| 6 | 1591 | .6998 | 126.8 | 1158.2 | 82.8 | 3.2 | -.4 | -.1 | -.1 | 85.4 | 77.1 | 4.5 | -.1 | -.1 | 81.4 |
| 7 | 1591 | .6998 | 132.8 | 1138.7 | 81.8 | 3.4 | -.3 | -.1 | -.1 | 84.7 | 74.9 | 4.8 | -.1 | -.1 | 79.5 |

TABLE A-13

TAKEOFF DATA

AIRCRAFT GULFSTREAM (COMMANDER) 900

SITE #1

TEST DATE 10-19-82

| A/C TEST DATA | | | | | SEL | | | | | | AL | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EVENT | RPM | $M_H$ | GS(KTS) | $ALT_T$(FT) | $SEL_{am}$ | $ALT_{corr}$ | $V_{corr}$ | $M_{H corr}$ | $P_{corr}$ | $SEL_{fc}$ | $AL_{am}$ | $ALT_{corr}$ | $M_{H corr}$ | $P_{corr}$ | $AL_{fc}$ |
| 15 | 1591 | .6920 | 116.1 | 1591.6 | 78.3 | .7 | -.4 | -.1 | 0 | 78.5 | 70.2 | 1.0 | -.1 | 0 | 71.1 |
| 16 | 1591 | .6920 | 117.7 | 1581.9 | 79.1 | .6 | -.4 | -.1 | 0 | 79.2 | 69.9 | .9 | -.1 | 0 | 70.7 |
| 17 | 1591 | .6920 | 118.4 | 1539.1 | 79.8 | .4 | -.4 | -.1 | 0 | 79.7 | 70.8 | .6 | -.1 | 0 | 71.3 |
| 18 | 1591 | .6920 | 113.6 | 1593.1 | 79.9 | .7 | -.5 | -.1 | 0 | 80.0 | 70.5 | 1.0 | -.1 | 0 | 71.4 |
| 19 | 1591 | .6920 | 125.0 | 1455.4 | 79.0 | 0 | -.2 | -.1 | 0 | 78.7 | 69.5 | 0 | -.1 | 0 | 69.4 |
| 20 | 1591 | .6920 | 119.0 | 1502.1 | 79.9 | .2 | -.4 | -.1 | 0 | 79.6 | 70.8 | .3 | -.1 | 0 | 71.0 |

TABLE A-14

TAKEOFF DATA

AIRCRAFT DUCHESS    SITE #1    TEST DATE 10-19-82

| A/C TEST DATA | | | | | SEL | | | | | | AL | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EVENT | RPM | $M_H$ | GS(KTS) | $ALT_T$(FT) | $SEL_{am}$ | $ALT_{corr}$ | $V_{corr}$ | $M_{H_{corr}}$ | $P_{corr}$ | $SEL_{fc}$ | $AL_{am}$ | $ALT_{corr}$ | $M_{H_{corr}}$ | $P_{corr}$ | $AL_{fc}$ |
| 29 | 2700 | .8091 | - | 1575 | 86.3 | 4.8 | 0 | .4 | .3 | 91.8 | 77.0 | 6.7 | .5 | .1 | 84.3 |
| 30 | 2700 | .8091 | - | 1372 | 87.4 | 3.7 | 0 | .4 | .3 | 91.8 | 79.4 | 5.3 | .5 | .1 | 85.3 |
| 31 | 2700 | .8091 | - | 1245 | 87.4 | 3.0 | 0 | .4 | .3 | 91.1 | 79.7 | 4.3 | .5 | .1 | 84.6 |
| 32 | 2700 | .8091 | - | 1432 | 87.4 | 4.1 | 0 | .4 | .3 | 92.2 | 78.4 | 5.8 | .5 | .1 | 84.8 |
| 33 | 2700 | .8091 | - | 1432 | 87.4 | 4.1 | 0 | .4 | .3 | 92.2 | 78.7 | 5.8 | .5 | .1 | 85.1 |
| 34 | 2700 | .8091 | - | 1454 | 86.1 | 4.2 | 0 | .4 | .3 | 91.0 | 77.3 | 5.9 | .5 | .1 | 83.8 |
| 35 | 2700 | .8091 | - | 1436 | 86.3 | 4.1 | 0 | .4 | .3 | 91.1 | 77.2 | 5.8 | .5 | .1 | 83.6 |

TABLE A-15

TAKEOFF DATA

AIRCRAFT NAVAJO 350 SITE #1 TEST DATE 10-20-82

| A/C TEST DATA | | | | | SEL | | | | | | AL | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EVENT | RPM | $M_H$ | GS(KTS) | $ALT_T$(FT) | $SEL_{am}$ | $ALT_{corr}$ | $V_{corr}$ | $M_{H corr}$ | $P_{corr}$ | $SEL_{fc}$ | $AL_{am}$ | $ALT_{corr}$ | $M_{H corr}$ | $P_{corr}$ | $AL_{fc}$ |
| 1 | 2525 | .8095 | 106 | - | 88.6 | - | | | | | 80.8 | - | - | - | |
| 2 | 2525 | .8080 | 101 | 1574 | 89.5 | 4.7 | 0 | .6 | -.1 | 94.7 | 79.5 | 6.7 | .8 | 0 | 87.0 |
| 3 | 2525 | .8080 | 101 | 1200 | 90.7 | 2.7 | 0 | .6 | -.1 | 93.9 | 83.7 | 3.8 | .9 | 0 | 88.4 |
| 4 | 2525 | .8080 | 101 | 1336 | 89.7 | 3.5 | 0 | .6 | -.1 | 93.7 | 81.6 | 5.0 | .9 | 0 | 87.5 |
| 5 | 2525 | .8077 | 100 | 1311 | 90.4 | 3.4 | 0 | .6 | -.1 | 94.3 | 82.9 | 4.8 | .9 | 0 | 88.6 |
| 6 | 2525 | .8086 | 103 | 1299 | 90.2 | 3.3 | 0 | .7 | -.1 | 94.1 | 82.2 | 4.7 | .9 | 0 | 87.8 |
| 7 | 2525 | .8080 | 101 | 1336 | 89.7 | 3.5 | 0 | .6 | -.1 | 93.7 | 81.5 | 5.0 | .9 | 0 | 87.4 |
| 8 | 2525 | .8080 | 101 | 1349 | 90.1 | 3.6 | 0 | .6 | -.1 | 94.2 | 82.6 | 5.1 | .9 | 0 | 88.6 |

TABLE A-16

TAKEOFF DATA

AIRCRAFT ARCHER II PA-28 181 SITE #1 TEST DATE 10-20-82

| A/C TEST DATA | | | | | SEL | | | | | | AL | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EVENT | RPM | $M_H$ | GS (KTS) | $ALT_T$ (FT) | $SEL_{am}$ | $ALT_{corr}$ | $V_{corr}$ | $M_{H corr}$ | $P_{corr}$ | $SEL_{fc}$ | $AL_{am}$ | $ALT_{corr}$ | $M_{H corr}$ | $P_{corr}$ | $AL_{fc}$ |
| 16 | 2350 | .7054 | 0 | 1233 | 82.1 | 4.6 | 0 | .1 | 0 | 86.8 | 70.9 | 6.5 | .1 | 0 | 77.5 |
| 17 | 2350 | .7127 | 0 | 1245 | 82.9 | 4.7 | 0 | -.2 | 0 | 87.4 | 72.6 | 6.6 | -.2 | 0 | 79.0 |
| 18 | 2350 | .7054 | 0 | 1298 | 83.1 | 5.0 | 0 | .1 | 0 | 88.5 | 73.0 | 7.1 | .1 | 0 | 80.2 |
| 19 | 2350 | .7059 | 0 | 1173 | 82.2 | 4.2 | 0 | .1 | 0 | 86.5 | 71.6 | 6.0 | .1 | 0 | 77.7 |
| 20 | 2350 | .7056 | 0 | 1271 | 83.0 | 4.8 | 0 | .1 | 0 | 87.9 | 72.0 | 6.8 | .1 | 0 | 78.9 |
| 21 | 2350 | .7054 | 0 | 1253 | 81.8 | 4.6 | 0 | .1 | 0 | 86.5 | 71.1 | 6.5 | .1 | 0 | 77.7 |

TABLE A-17

TAKEOFF DATA

AIRCRAFT BONANZA A-36

SITE #1

TEST DATE 10-20-82

| A/C TEST DATA | | | | | SEL | | | | | | AL | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EVENT | RPM | $M_H$ | GS (KTS) | $ALT_T$ (FT) | $SEL_{am}$ | $ALT_{corr}$ | $V_{corr}$ | $M_{H_{corr}}$ | $P_{corr}$ | $SEL_{fc}$ | $AL_{am}$ | $ALT_{corr}$ | $M_{H_{corr}}$ | $P_{corr}$ | $AL_{fc}$ |
| 30 | 2700 | .8511 | 0 | 1062 | 90.2 | 2.9 | 0 | .2 | .1 | 93.4 | 83.4 | 4.1 | .4 | 0 | 87.9 |
| 32 | 2700 | .8519 | 0 | 1243 | 88.9 | 4.0 | 0 | .2 | .1 | 93.2 | 80.9 | 5.7 | .3 | 0 | 86.9 |
| 33 | 2700 | .8511 | 0 | 1192 | 88.6 | 3.7 | 0 | .2 | .1 | 92.6 | 81.6 | 5.3 | .4 | 0 | 87.3 |
| 34 | 2700 | .8509 | 0 | 1270 | 88.5 | 4.2 | 0 | .3 | .1 | 93.1 | 80.4 | 5.9 | .4 | 0 | 86.7 |
| 35 | 2700 | .8514 | 0 | 1145 | 89.3 | 3.5 | 0 | .2 | .1 | 93.1 | 81.5 | 4.9 | .3 | 0 | 86.7 |
| 36 | 2700 | .8511 | 0 | 1217 | 89.4 | 3.9 | 0 | .2 | .1 | 93.6 | 82.2 | 5.5 | .4 | 0 | 88.1 |

TABLE A-18

TAKEOFF DATA

AIRCRAFT C-425 CONQUEST-I [illegible] #2 TEST DATE 10-26-82

| A/C TEST DATA | | | | | SEL | | | | | | AL | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EVENT | RPM | $M_H$ | GS(KTS) | $ALT_T$(FT) | $SEL_{am}$ | $ALT_{corr}$ | $V_{corr}$ | $M_{H\,corr}$ | $P_{corr}$ | $SEL_{fc}$ | $AL_{am}$ | $ALT_{corr}$ | $M_{H\,corr}$ | $P_{corr}$ | $AL_{fc}$ |
| 1 | 1900 | ,7220 | 90 | 1240 | 79.6 | .9 | -.7 | -.1 | -.1 | 79.6 | 71.9 | 1.4 | -.1 | -.2 | 73.0 |
| 2 | 1900 | .7236 | 94 | 1260 | 80.1 | 1.1 | -.6 | -.1 | -.1 | 80.4 | 72.2 | 1.5 | -.1 | -.2 | 73.4 |
| 3 | 1900 | .7220 | 90 | 1349 | 80.2 | 1.6 | -.7 | -.1 | -.1 | 80.9 | 71.9 | 2.2 | -.1 | -.2 | 73.8 |
| 4 | 1900 | .7224 | 91 | 1424 | 80.9 | 2.0 | -.7 | -.1 | -.1 | 82.0 | 71.5 | 2.8 | -.1 | -.2 | 72.5 |
| 5 | 1900 | .7236 | 90 | 1303 | 80.0 | 1.3 | -.7 | -.1 | -.1 | 80.4 | 71.5 | 1.9 | -.1 | -.2 | 72.4 |
| 6 | 1900 | .7228 | 92 | 1464 | 79.2 | 2.2 | -.7 | -.1 | -.1 | 80.5 | 70.7 | 3.1 | -.1 | -.2 | 71.8 |
| 7 | 1900 | .7231 | 93 | 1464 | 79.8 | 2.2 | -.6 | -.1 | -.1 | 81.2 | 71.3 | 3.1 | -.1 | -.2 | 72.3 |

APPENDIX B

500 FT. LEVEL FLYOVER DATA

## Appendix B: Level Flyover Noise Data

This appendix contains as measured noise data along with other pertinent information used in arriving at fully corrected level flyover noise levels.

### Abbreviations used in Appendix B

| | |
|---|---|
| RPM: | Propeller RPM (revolutions per minute) |
| GS: | Ground Speed expressed in knots |
| IAS: | Indicated Air Speed expressed in knots |
| $M_H$: | Helical Tip Mach Number |
| $ALT_T$: | Test Altitude (AGL) |
| $AL_{am}$: | As Measured A-weighted Sound Level |
| $AL_{fc}$: | Fully corrected A-weighted Sound Level |
| $SEL_{am}$: | As measured Sound Exposure Level |
| $SEL_{fc}$: | Fully corrected A-weighted Sound Level |

500 FT. LEVEL FLYOVER DATA

TABLE B-1

TEST DATE 6-23-82

AIRCRAFT C-170

| | AIRCRAFT TEST DATA | | | | | | NOISE DATA SITE 1 | | | | | NOISE DATA SITE 2 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | GS (KTS) | | | | | | | | | | | | | |
| EVENT | % PWR | RPM | SITE 1 | SITE 2 | IAS (KTS) | $M_H$ | $ALT_T$ (ft) | $AL_{am}$ | $AL_{fc}$ | $SEL_{am}$ | $SEL_{fc}$ | $ALT_T$ (ft) | $AL_{am}$ | $AL_{fc}$ | $SEL_{am}$ | $SEL_{fc}$ |
| 9 | 65 | 2450 | 88 | | 109 | .725 | 199 | 80.9 | 76.6 | 85.5 | 81.5 | 210 | 79.2 | 75.9 | 84.1 | 81.8 |
| 10 | 65 | 2450 | 88 | | 109 | .724 | 216 | 81.2 | 77.8 | 85.1 | 81.7 | 216 | 78.4 | 75.0 | 83.3 | 80.8 |
| 11 | 65 | 2450 | 88 | | 109 | .724 | 264 | 79.0 | 79.0 | 84.5 | 82.6 | 264 | 76.1 | 74.8 | 81.5 | 80.4 |
| 12 | 55 | 2225 | 67 | | 91 | .657 | 294 | 72.9 | 72.7 | 80.8 | 81.2 | 301 | 71.9 | 71.9 | 78.7 | 78.1 |
| 13 | 55 | 2225 | 69 | | 91 | .657 | 281 | 74.4 | 73.7 | 81.5 | 81.4 | 292 | 72.8 | 72.8 | 79.3 | 78.6 |
| 14 | - | 2175 | 66 | | 85 | .620 | 279 | - | - | - | - | 306 | 70.2 | 70.4 | 77.1 | 76.6 |
| 15 | 45 | 1900 | 57 | | 74 | .561 | 273 | 69.9 | 68.9 | 79.0 | 79.2 | 272 | 70.2 | 69.2 | 77.5 | 75.8 |
| 16 | 45 | 1900 | - | | 78 | .561 | 292 | 69.9 | 69.6 | 79.0 | - | 292 | 67.9 | 67.6 | 75.9 | 74.8 |
| 17 | 45 | 1900 | 59 | | 74 | .560 | 280 | 70.4 | 69.7 | 79.2 | 79.5 | 275 | 70.3 | 69.4 | 78.6 | 76.8 |
| 18 | 65 | 2450 | 81.1 | | 104 | .720 | 415 | 74.7 | 78.1 | 82.4 | 84.7 | 445 | 73.0 | 77.1 | 80.0 | 80.0 |
| 19 | 65 | 2450 | 79 | | 104 | .724 | 449 | 73.8 | 78.0 | 82.0 | 85.0 | 482 | 71.2 | 76.1 | 78.9 | 79.5 |
| 21 | 65 | 2450 | 80 | | - | .724 | 454 | - | - | - | - | 471 | 71.5 | 76.2 | 79.0 | 79.4 |
| 22 | - | 2450 | 79 | | 104 | .725 | 600 | - | - | - | - | 609 | 71.2 | 71.4 | 78.7 | 78.8 |
| 23 | - | 2450 | 74 | | 102 | .724 | 632 | - | - | - | - | 599 | 71.1 | 71.1 | 78.8 | 78.8 |
| 24 | - | 2450 | 79 | | 104 | .724 | 570 | 71.4 | 70.9 | 80.2 | 79.8 | 610 | 70.2 | 70.2 | 78.0 | 77.9 |

500 FT. LEVEL FLYOVER DATA

TABLE B-2

AIRCRAFT PA-28 Turbo Arrow IV

TEST DATE 7-13-82 and 7-20-82

| AIRCRAFT TEST DATA | | | | | | | NOISE DATA SITE 1 | | | | | NOISE DATA SITE 2 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | GS (KTS) | | | | | | | | | | | | | |
| EVENT | % PWR | RPM | SITE 1 | SITE 2 | IAS (KTS) | $M_H$ | $ALT_T$ (ft) | $AL_{am}$ | $AL_{fc}$ | $SEL_{am}$ | $SEL_{fc}$ | $ALT_T$ (ft) | $AL_{am}$ | $AL_{fc}$ | $SEL_{am}$ | $SEL_{fc}$ |
| 5.8 | 55 | 2500 | 83 | 86 | 95 | .7449 | 510 | 74.2 | 74.4 | 80.9 | 80.4 | 532 | 74.1 | 74.7 | 80.9 | 80.9 |
| 5.9 | 55 | 2500 | 86 | 86 | 96 | .7458 | 532 | 74.1 | 74.7 | 80.8 | 80.8 | 534 | 74.0 | 74.7 | 80.9 | 80.9 |
| 6.13 | 55 | 2400 | 119 | 119 | 120 | .7272 | 467 | 71.7 | 71.0 | 76.3 | 76.1 | 503 | 69.9 | 70.0 | 76.3 | 76.8 |
| 6.14 | 55 | 2400 | 119 | 117 | 119 | .7272 | 482 | 71.7 | 71.3 | 76.1 | 76.5 | 513 | 70.1 | 70.4 | 76.1 | 76.7 |
| 6.15 | 55 | 2400 | 121 | 121 | 121 | .7281 | 531 | 71.2 | 71.8 | 75.6 | 76.5 | 541 | 69.0 | 69.8 | 75.6 | 76.7 |
| 5.10 | 55 | 2400 | 88 | 88 | 98 | .7176 | 504 | 72.7 | 72.8 | 79.6 | 79.3 | 532 | 71.5 | 72.1 | 79.4 | 79.5 |
| 5.11 | 55 | 2400 | 88 | 90 | 97 | .7176 | 516 | 72.1 | 72.4 | 78.7 | 78.5 | 536 | 71.8 | 72.5 | 78.1 | 78.2 |
| 6.16 | 55 | 2300 | 120 | 120 | 120 | .6997 | 498 | 69.4 | 69.4 | 76.2 | 76.7 | 508 | 68.2 | 68.4 | 75.5 | 76.1 |
| 6.17 | 55 | 2300 | 120 | 120 | 120 | .6997 | 498 | 69.8 | 69.7 | 76.6 | 77.0 | 506 | 68.2 | 68.3 | 75.5 | 76.1 |
| 5.12 | 55 | 2300 | 91 | 90 | 100 | .6893 | 498 | 70.6 | 70.6 | 78.6 | 78.2 | 521 | 70.4 | 70.8 | 78.2 | 78.1 |
| 5.13 | 55 | 2300 | 87 | 90 | 98 | .6893 | 535 | 70.3 | 71.0 | 78.7 | 78.7 | 531 | 69.9 | 70.5 | 78.3 | 78.3 |

# 500 FT. LEVEL FLYOVER DATA

## TABLE B-2 (CONT)

AIRCRAFT PA-28 Turbo Arrow IV (CONT)

TEST DATE 7-13-82 and 7-20-82

| AIRCRAFT TEST DATA | | | | | | | | NOISE DATA SITE 1 | | | | | NOISE DATA SITE 2 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | GS (KTS) | | | | | | | | | | | | | | |
| EVENT | % PWR | RPM | SITE 1 | SITE 2 | IAS (KTS) | $M_H$ | $ALT_T$ (ft) | $AL_{sm}$ | $AL_{fc}$ | $SEL_{sm}$ | $SEL_{fc}$ | $ALT_T$ (ft) | $AL_{sm}$ | $AL_{fc}$ | $SEL_{sm}$ | $SEL_{fc}$ |
| 6.1 | 75 | 2575 | 133 | 133 | 138 | .7839 | 491 | - | | 80.6 | 80.4 | 501 | 76.4 | 76.4 | 80.6 | 80.5 |
| 6.2 | 75 | 2575 | 133 | 133 | 138 | .7839 | 506 | - | | - | | 516 | - | | - | - |
| 6.3 | 75 | 2575 | 133 | 135 | 140 | .7848 | 467 | 77.7 | 77.0 | 81.1 | 81.1 | 486 | 76.8 | 76.5 | 81.1 | 80.9 |
| 6.4 | 75 | 2500 | 136 | 142 | 142 | .7644 | 504 | 75.9 | 76.0 | 79.2 | 79.3 | 481 | 74.8 | 74.4 | 79.2 | 79.0 |
| 6.5 | 75 | 2500 | 136 | 136 | 141 | .7635 | 481 | 75.4 | 75.0 | 79.2 | 78.9 | 491 | 74.2 | 74.0 | 79.2 | 79. |
| 6.6 | 75 | 2450 | 140 | 142 | 142 | .7511 | 507 | 74.3 | 74.4 | 78.6 | 78.8 | 506 | 73.7 | 73.9 | 78.6 | 78.8 |
| 6.7 | 75 | 2450 | 134 | 136 | 140 | .7502 | 490 | 74.2 | 74.0 | 78.7 | 78.6 | 471 | 73.4 | 72.8 | 78.7 | 78.3 |
| 6.8 | 75 | 2400 | 137 | 137 | 142 | .7360 | 472 | 73.8 | 73.2 | 78.0 | 77.6 | 482 | 72.5 | 72.1 | 78.0 | 77.7 |
| 6.9 | 75 | 2400 | 136 | 136 | 140 | .7352 | 462 | 73.7 | 72.9 | 78.0 | 77.4 | 475 | 72.3 | 71.8 | 78.0 | 77.6 |
| | | | | | | | | | | | | | | | | |
| 6.10 | 100 | 2575 | 149 | 149 | 162 | .7945 | 432 | 80.8 | 79.3 | 82.6 | 81.5 | 442 | 78.9 | 77.6 | 82.6 | 81.7 |
| 6.11 | 100 | 2575 | 147 | 148 | 160 | .7936 | 465 | 78.7 | 77.9 | 82.1 | 81.6 | 465 | 78.1 | 77.3 | 82.1 | 81.6 |
| 6.12 | 100 | 2575 | 147 | 147 | 160 | .7936 | 448 | 79.5 | 78.4 | 82.3 | 81.5 | 458 | 78.3 | 77.4 | 82.3 | 81.7 |

500 FT. LEVEL FLYOVER DATA

TABLE B-3

AIRCRAFT C-180 TEST DATE 7-20-82

| | AIRCRAFT TEST DATA | | | | | | NOISE DATA SITE 1 | | | | | NOISE DATA SITE 2 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | GS (KTS) | | | | | | | | | | | | | |
| EVENT | % PWR | RPM | SITE 1 | SITE 2 | IAS (KTS) | $M_H$ | $ALT_T$ (ft) | $AL_{am}$ | $AL_{fc}$ | $SEL_{am}$ | $SEL_{fc}$ | $ALT_T$ (ft) | $AL_{am}$ | $AL_{fc}$ | $SEL_{am}$ | $SEL_{fc}$ |
| 21 | 100 | 2600 | 131.2 | 134.6 | 165 | .85 | 432 | 82.1 | 80.6 | 86.9 | 86.2 | 477 | - | - | - | - |
| 22 | 100 | 2600 | 131.2 | 134.6 | 162 | .85 | 461 | 82.7 | 81.9 | 87.6 | 87.4 | 506 | 83.2 | 83.3 | 87.9 | 88.5 |
| 23 | 100 | 2600 | 131.2 | 134.6 | 160 | .85 | 459 | 83.0 | 82.1 | 87.6 | 87.4 | 504 | 83.2 | 83.3 | 87.8 | 88.3 |
| 24 | 100 | 2600 | 131.2 | 134.6 | 163 | .85 | 471 | 83.5 | 82.9 | 87.9 | 87.8 | 516 | 83.5 | 83.8 | 88.2 | 88.9 |
| | | | | | | | | | | | | | | | | |
| 25 | 75 | 2550 | - | - | 148 | .82 | - | 82.2 | - | 86.7 | - | - | 82.4 | - | 87.1 | - |
| 26 | 75 | 2600 | 123.6 | 123.9 | 145 | .84 | 479 | 81.1 | 80.7 | 85.9 | 85.8 | 519 | 82.0 | 82.4 | 86.8 | 87.3 |
| 27 | 75 | 2600 | 118.1 | 122.2 | 148 | .84 | 471 | 81.4 | 80.8 | 86.2 | 85.8 | 514 | 81.9 | 82.2 | 86.8 | 87.2 |
| 28 | 75 | 2425 | 120 | 125.2 | 151 | .79 | 503 | 78.3 | 78.4 | 84.2 | 84.4 | 524 | 78.9 | 79.4 | 84.4 | 85.1 |
| 29 | 75 | 2450 | 116.1 | 122.1 | 151 | .80 | 506 | - | - | - | - | 547 | 78.6 | 79.5 | 84.3 | 85.1 |
| 30 | 75 | 2450 | 121 | 124.8 | 153 | .80 | 505 | 77.8 | 77.9 | 83.9 | 84.1 | 527 | 78.8 | 79.3 | 84.4 | 85.0 |
| | | | | | | | | | | | | | | | | |
| 31 | 50 | 2450 | 93.6 | 95.6 | 120 | .78 | 508 | 74.7 | 74.8 | 81.4 | 80.9 | 553 | 75.8 | 76.9 | 82.2 | 82.4 |
| 32 | 50 | 2425 | 93.6 | 95.6 | 119 | .77 | 530 | 75.9 | 76.5 | 82.2 | 82.0 | 547 | 76.6 | 77.5 | 82.7 | 82.8 |
| 33 | 50 | 2400 | - | 100 | 125 | .77 | - | 74.9 | - | 81.3 | - | 550 | 75.3 | - | 81.7 | 82.0 |
| 34 | 50 | 2350 | 103.3 | 103 | 130 | .76 | 477 | 74.4 | 73.9 | 80.5 | 79.8 | 520 | 74.2 | 74.6 | 80.8 | 80.7 |
| 35 | 50 | 2300 | 101.3 | 105.4 | 131 | .74 | 509 | 73.4 | 73.6 | 80.0 | 79.7 | 525 | 73.3 | 73.8 | 80.1 | 80.2 |
| 36 | 50 | 2200 | 104.8 | 104.9 | 124 | .71 | 513 | 71.4 | 71.7 | 78.5 | 78.4 | 539 | 71.8 | 72.6 | 79.0 | 79.3 |

500 FT. LEVEL FLYOVER DATA

TABLE B-4

AIRCRAFT PA-38 Tomahawk

TEST DATE 8-10-82

| | AIRCRAFT TEST DATA | | | | | | NOISE DATA SITE 1 | | | | | NOISE DATA SITE 2 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | GS (KTS) | | | | | | | | | | | | | |
| EVENT | % PWR | RPM | SITE 1 | SITE 2 | IAS (KTS) | $M_H$ | $ALT_T$ (ft) | $AL_{am}$ | $AL_{fc}$ | $SEL_{am}$ | $SEL_{fc}$ | $ALT_T$ (ft) | $AL_{am}$ | $AL_{fc}$ | $SEL_{am}$ | $SEL_{fc}$ |
| 16 | 75 | 2410 | 100 | 102 | 98 | .678 | 526 | 70.4 | 70.9 | 78.0 | 78.7 | 551 | 70.0 | 71.0 | 77.5 | 78.6 |
| 17 | 75 | 2410 | 98 | 99 | 100 | .679 | 572 | 70.3 | 71.7 | 77.9 | 79.1 | 569 | 69.7 | 71.0 | 78.2 | 79.4 |
| | | | | | | | | | | | | | | | | |
| 18 | 70 | 2350 | 95 | 94 | 95 | .661 | 541 | 69.2 | 70.0 | 77.5 | 78.2 | 551 | 69.3 | 70.3 | 77.3 | 78.1 |
| 19 | 70 | 2350 | 100 | 96 | 97 | .662 | 554 | 67.8 | 68.9 | 76.1 | 77.1 | 533 | 69.5 | 70.2 | 77.1 | 77.7 |
| | | | | | | | | | | | | | | | | |
| 20 | 65 | 2300 | 88 | 91 | 90 | .647 | 525 | 67.3 | 67.8 | 75.5 | 75.8 | 553 | 68.0 | 69.1 | 76.1 | 76.8 |
| 21 | 65 | 2300 | 86 | 87 | 90 | .647 | 558 | 68.2 | 69.3 | 76.2 | 76.8 | 580 | 68.1 | 69.6 | 76.2 | 77.1 |
| | | | | | | | | | | | | | | | | |
| 22 | 55 | 2170 | 80 | 87 | 85 | .610 | 555 | 65.9 | 67.0 | 74.6 | 75.0 | 565 | 66.7 | 68.0 | 74.6 | 75.4 |
| 23 | 55 | 2170 | 83 | 87 | 85 | .610 | 564 | 65.9 | 67.1 | 74.4 | 75.0 | 571 | 66.6 | 68.0 | 74.9 | 75.7 |

# 500 FT. LEVEL FLYOVER DATA

## TABLE B-5

AIRCRAFT King Air 200 TEST DATE 8-31-82

| AIRCRAFT TEST DATA | | | | | | | NOISE DATA SITE 1 | | | | | NOISE DATA SITE 2 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EVENT | % PWR | RPM | GS (KTS) SITE 1 | GS (KTS) SITE 2 | IAS (KTS) | $M_H$ | $ALT_T$ (ft) | $AL_{am}$ | $AL_{fc}$ | $SEL_{am}$ | $SEL_{fc}$ | $ALT_T$ (ft) | $AL_{am}$ | $AL_{fc}$ | $SEL_{am}$ | $SEL_{fc}$ |
| 8 | 85 | 1700 | | | 235 | .740 | 552 | 81.4 | 82.4 | 84.5 | 85.3 | 582 | 80.7 | 82.3 | 84.7 | 85.8 |
| 9 | 85 | 1750 | | | 235 | .757 | 488 | 82.1 | 81.8 | 86.0 | 85.8 | 564 | 81.4 | 82.7 | 85.5 | 86.4 |
| 10 | 85 | 1800 | | | 230 | .770 | 490 | 82.9 | 82.7 | 86.0 | 85.9 | 524 | 83.2 | 83.7 | 86.9 | 87.2 |
| 11 | 85 | 1850 | | | 232 | .789 | 557 | 81.5 | 82.6 | 84.7 | 85.5 | 578 | 83.2 | 84.7 | 86.8 | 87.9 |
| 12 | 85 | 1900 | | | 232 | .806 | 572 | 82.6 | 84.0 | 85.6 | 86.6 | 597 | 82.5 | 84.3 | 86.0 | 87.3 |
| 13 | 85 | 1950 | | | 231 | .823 | 455 | 86.0 | 85.0 | 88.4 | 87.7 | 504 | 84.1 | 84.2 | 87.5 | 87.6 |
| 14 | 85 | 2000 | | | 234 | .842 | 453 | 86.4 | 85.4 | 88.7 | 88.0 | 506 | 86.0 | 86.1 | 89.1 | 89.2 |
| 15 | 85 | 1900 | | | 233 | .807 | 466 | 83.4 | 82.7 | 86.6 | 86.1 | 554 | 82.2 | 83.3 | 86.2 | 87.0 |
| 16 | 85 | 1950 | | | 232 | .823 | 510 | 82.6 | 82.8 | 84.7 | 82.9 | 506 | 83.8 | 83.9 | 87.3 | 87.4 |
| 17 | 85 | 2000 | | | 233 | .841 | 519 | 85.2 | 85.6 | 87.1 | 87.4 | 578 | 83.9 | 85.4 | 87.3 | 88.4 |
| | | | | | | | | | | | | | | | | |
| 18 | 95 | 1900 | | | 238 | .810 | 490 | 85.6 | 85.4 | 87.9 | 87.8 | 617 | 81.9 | 84.1 | 86.1 | 87.7 |
| 19 | 95 | 1900 | | | 240 | .811 | 488 | 83.5 | 83.2 | 86.4 | 86.2 | 552 | 83.4 | 84.4 | 85.9 | 86.6 |
| 20 | 95 | 1900 | | | 239 | .810 | 530 | 83.0 | 83.6 | 86.1 | 86.5 | 550 | 83.1 | 84.1 | 87.0 | 87.7 |
| 21 | 95 | 1900 | | | 239 | .810 | 496 | 84.4 | 84.3 | 87.2 | 87.1 | 509 | 82.8 | 83.0 | 86.7 | 86.8 |

500 FT. LEVEL FLYOVER DATA

TABLE B-6

AIRCRAFT King Air 200 (CONT) TEST DATE 8-31-82

| AIRCRAFT TEST DATA | | | | | | | NOISE DATA SITE 1 | | | | | NOISE DATA SITE 2 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| EVENT | % PWR | RPM | GS (KTS) SITE 1 | GS (KTS) SITE 2 | IAS (KTS) | $M_H$ | $ALT_T$ (ft) | $AL_{am}$ | $AL_{fc}$ | $SEL_{am}$ | $SEL_{fc}$ | $ALT_T$ (ft) | $AL_{am}$ | $AL_{fc}$ | $SEL_{am}$ | $SEL_{fc}$ |
| 22 | 71 | 1900 | | | 214 | .795 | 525 | 80.7 | 81.2 | 83.5 | 83.9 | 543 | 80.7 | 81.6 | 86.5 | 87.1 |
| 23 | 71 | 1900 | | | 214 | .795 | 525 | 81.2 | 81.7 | 84.2 | 84.6 | 492 | 81.1 | 80.9 | 85.6 | 85.5 |
| 24 | 71 | 1900 | | | 215 | .795 | 493 | 81.3 | 81.2 | 83.6 | 83.5 | 520 | 80.3 | 80.7 | 84.3 | 84.3 |
| 25 | 71 | 1900 | | | 214 | .795 | 482 | 80.9 | 80.5 | 84.2 | 83.9 | 528 | 81.9 | 82.5 | 85.9 | 86.3 |
| | | | | | | | | | | | | | | | | |
| 26 | 47 | 1900 | | | 195 | .783 | 496 | 81.0 | 80.9 | 83.8 | 83.7 | 537 | 80.1 | 80.8 | 84.7 | 85.2 |
| 27 | 47 | 1900 | | | 194 | .783 | 505 | 80.3 | 80.4 | 83.8 | 83.9 | 556 | 79.8 | 80.9 | 84.7 | 85.5 |
| 28 | 47 | 1900 | | | 194 | .783 | 523 | 79.1 | 79.6 | 82.9 | 83.2 | 560 | 79.4 | 80.6 | 84.0 | 84.8 |
| 29 | 47 | 1900 | | | 195 | .783 | 519 | 78.3 | 78.7 | 81.3 | 81.6 | 522 | 80.9 | 81.3 | 85.3 | 85.6 |

500 FT. LEVEL FLYOVER DATA

TABLE B-7

AIRCRAFT PA-42 Cheyenne

TEST DATE 9-8-82

| AIRCRAFT TEST DATA | | | | | | | NOISE DATA SITE 1 | | | | | NOISE DATA SITE 2 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | GS (KTS) | | | | | | | | | | | | | |
| EVENT | % PWR | RPM | SITE 1 | SITE 2 | IAS (KTS) | $M_H$ | $ALT_T$ (ft) | $AL_{am}$ | $AL_{fc}$ | $SEL_{am}$ | $SEL_{fc}$ | $ALT_T$ (ft) | $AL_{am}$ | $AL_{fc}$ | $SEL_{am}$ | $SEL_{fc}$ |
| 1 | 100 | 2000 | 248.3 | 247.1 | 240 | .821 | 548 | 83.7 | 84.7 | 86.6 | 87.3 | 555 | 85.4 | 86.5 | 88.1 | 88.9 |
| 2 | 100 | 1950 | 252.8 | 248.3 | 236 | .802 | 551 | 83.4 | 84.4 | 86.9 | 87.7 | 551 | 83.6 | 84.6 | 86.8 | 87.6 |
| 3 | 100 | 1900 | 236.2 | 240.3 | 236 | .785 | 593 | 82.2 | 84.0 | 85.2 | 86.4 | 553 | 82.4 | 83.5 | 85.6 | 86.4 |
| 4 | 100 | 1850 | 241.4 | 239.9 | 236 | .769 | 561 | 82.2 | 83.4 | 85.3 | 86.2 | 592 | 81.2 | 83.0 | 85.0 | 86.2 |
| 5 | 100 | 1800 | - | - | 236 | .769 | - | 81.3 | - | 84.6 | - | - | 80.7 | - | 84.6 | - |
| 6 | 100 | 1800 | 238.2 | 240.2 | 230 | .765 | 564 | - | - | - | - | 580 | 80.5 | 82.1 | 84.6 | 85.7 |
| 7 | 100 | 1750 | 242.1 | 242.5 | 230 | .732 | 548 | 80.9 | 81.8 | 84.5 | 85.2 | 550 | 80.6 | 81.6 | 84.8 | 85.5 |
| 8 | 100 | 1700 | 234.9 | 241.8 | 231 | .717 | 573 | - | - | - | - | 556 | 80.1 | 81.2 | 84.6 | 85.4 |
| 9 | 100 | 1850 | 238 | 244.3 | 231 | .766 | 528 | 81.3 | 81.9 | 85.1 | 85.5 | 566 | 81.8 | 83.1 | 85.4 | 86.3 |
| | | | | | | | | | | | | | | | | |
| 10 | 100 | 1900 | 212 | 219.1 | 210 | .769 | 522 | 80.1 | 80.5 | 84.8 | 84.6 | 580 | 79.8 | 81.4 | 84.4 | 85.4 |
| 11 | 100 | 1900 | 217.3 | 217.3 | 210 | .769 | 587 | 80.6 | 82.3 | 85.1 | 86.2 | 588 | 80.9 | 82.6 | 85.2 | 86.3 |
| 12 | 100 | 1900 | 214.9 | 227.5 | 210 | .769 | 555 | 80.6 | 81.7 | 84.9 | 85.4 | 583 | 80.6 | 82.2 | 84.7 | 85.8 |
| 13 | 100 | 1900 | 221.1 | 223.6 | 210 | .769 | 478 | 81.3 | 80.8 | 85.4 | 85.2 | 573 | 80.8 | 82.2 | 84.9 | 35.9 |
| 14 | 100 | 1900 | 230.2 | 238 | - | - | 572 | 80.9 | 82.3 | 85.1 | 86.9 | 567 | 81.2 | 82.5 | 85.4 | 86.5 |

500 FT. LEVEL FLYOVER DATA

TABLE B-7 (CONT)

AIRCRAFT P-42 Cheyenne (CONT)

TEST DATE 9-8-82

| | AIRCRAFT TEST DATA | | | | | | NOISE DATA SITE 1 | | | | | NOISE DATA SITE 2 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | GS (KTS) | | | | | | | | | | | | | |
| EVENT | % PWR | RPM | SITE 1 | SITE 2 | IAS (KTS) | $M_H$ | $ALT_T$ (ft) | $AL_{am}$ | $AL_{fc}$ | $SEL_{am}$ | $SEL_{fc}$ | $ALT_T$ (ft) | $AL_{am}$ | $AL_{fc}$ | $SEL_{am}$ | $SEL_{fc}$ |
| 15 | 75 | 1900 | 212 | 218 | 209 | .768 | 551 | 80.0 | 81.0 | 83.9 | 84.7 | 541 | 79.3 | 80.1 | 83.6 | 84.2 |
| 16 | 75 | 1900 | 200 | 201 | 210 | .769 | 510 | 80.0 | 80.2 | 81.5 | 81.5 | 543 | 79.7 | 80.6 | 83.6 | 84.2 |
| 17 | 75 | 1900 | 201 | 204 | 205 | .765 | 584 | 80.0 | 81.6 | 83.8 | 85.8 | 592 | 79.1 | 80.9 | 83.1 | 84.3 |
| 18 | 75 | 1900 | - | - | 203 | .764 | - | 80.0 | - | 84.0 | - | - | 79.1 | - | 83.3 | - |
| 19 | 75 | 1900 | 208 | 210 | 205 | .765 | 537 | 79.1 | 79.8 | 83.4 | 83.9 | 552 | 79.1 | 80.1 | 83.4 | 84.1 |
| 20 | 50 | 1900 | 190 | 185 | 183 | .753 | 531 | 77.3 | 77.9 | 82.2 | 82.6 | 521 | 77.5 | 77.9 | 82.2 | 82.5 |
| 21 | 50 | 1900 | 187 | 187 | 183 | .753 | 523 | 76.0 | 76.5 | 81.0 | 81.3 | 502 | 77.6 | 77.6 | 82.3 | 82.3 |

500 FT. LEVEL FLYOVER DATA

TABLE B-8

AIRCRAFT C-414 Chancellor

TEST DATE 9-14-82

| AIRCRAFT TEST DATA | | | | | | | NOISE DATA SITE 1 | | | | | NOISE DATA SITE 2 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| :VENT | % PWR | RPM | GS (KTS) SITE 1 | GS (KTS) SITE 2 | IAS (KTS) | $M_H$ | $ALT_T$ (ft) | $AL_{am}$ | $AL_{fc}$ | $SEL_{am}$ | $SEL_{fc}$ | $ALT_T$ (ft) | $AL_{am}$ | $AL_{fc}$ | $SEL_{am}$ | $SEL_{fc}$ |
| 1 | 89 | 2700 | 166 | 171 | 170 | .840 | 522 | - | - | - | - | 498.4 | 84.1 | 84.1 | 88.1 | 88.0 |
| 2 | 89 | 2650 | 175 | 170 | 176 | .829 | 491.3 | 83.7 | 83.5 | 87.6 | 87.6 | 498.3 | 84.3 | 84.3 | 87.9 | 87.8 |
| 3 | 89 | 2600 | 171 | 188 | 176 | .815 | 500.5 | 80.6 | 80.6 | 85.5 | 85.5 | 564 | 83.2 | 84.5 | 87.5 | 88.6 |
| 4 | 89 | 2550 | 174 | 175 | 175 | .801 | 488.8 | 80.1 | 79.9 | 85.1 | 85.0 | 498.2 | 82.0 | 82.0 | 86.2 | 86.2 |
| 18 | 89 | 2700 | 168 | 170 | 175 | .842 | 482.4 | 83.5 | 83.1 | 87.7 | 87.3 | 461.9 | 86.1 | 85.3 | 90.4 | 89.7 |
| | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| 6 | 75 | 2600 | 152 | 151 | 154 | .805 | 505.9 | 78.9 | 79.0 | 83.5 | 83.5 | 475.4 | 81.9 | 81.4 | 85.9 | 85.5 |
| 7 | 75 | 2500 | 159 | 152 | 160 | .779 | 518.7 | 79.7 | 80.1 | 84.5 | 84.8 | 485.4 | 79.7 | 79.4 | 84.5 | 84.3 |
| 8 | 75 | 2450 | 159 | 155 | 160 | .765 | 490.5 | 77.4 | 77.2 | 83.5 | 83.4 | 480.7 | 81.8 | 81.4 | 86.1 | 85.9 |
| 10 | 75 | 2300 | 161 | 173 | 162 | .724 | 493 | 76.5 | 76.4 | 83.0 | 83.0 | 579.0 | 78.7 | 80.2 | 83.8 | 85.3 |
| 11 | 75 | 2250 | 162 | 159 | 163 | .710 | 504.4 | 75.0 | 75.1 | 82.0 | 82.2 | 469 | 77.2 | 76.5 | 83.0 | 82.7 |
| 19 | 75 | 2700 | 145 | 144 | 147 | .830 | 525.1 | 83.1 | 83.6 | 86.9 | 87.1 | 479.4 | 83.2 | 82.8 | 86.8 | 86.4 |
| 20 | 75 | 2500 | 156 | 119 | 162 | .780 | 495 | 78.4 | 78.3 | 83.7 | 83.6 | 519.4 | 79.8 | 80.2 | 84.8 | 84.4 |

500 FT. LEVEL FLYOVER DATA

TABLE B-6 (CONT)

AIRCRAFT C-414 Chancellor (CONT)

TEST DATE 9-14-82

| AIRCRAFT TEST DATA | | | | | | | NOISE DATA SITE 1 | | | | | NOISE DATA SITE 2 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | GS (KTS) | | IAS | | | | | | | | | | | |
| EVENT | % PWR | RPM | SITE 1 | SITE 2 | (KTS) | $M_H$ | $ALT_T$ (ft) | $AL_{am}$ | $AL_{fc}$ | $SEL_{am}$ | $SEL_{fc}$ | $ALT_T$ (ft) | $AL_{am}$ | $AL_{fc}$ | $SEL_{am}$ | $SEL_{fc}$ |
| 13 | 52 | 2400 | 115 | 114 | 120 | .734 | 519.5 | 75.5 | 73.4 | 81.7 | 81.9 | 500.4 | 75.0 | | 81.0 | 80.9 |
| 14 | 52 | 2350 | 115 | 116 | 118 | .718 | 499.8 | 75.3 | 75.3 | 81.3 | 81.2 | 511.2 | 72.5 | | 79.7 | 79.8 |
| 16 | 52 | 2250 | 123 | 121 | 118 | .690 | 486.3 | 72.6 | 72.3 | 79.5 | 79.4 | 564.0 | 72.1 | | 79.8 | 80.7 |
| 17 | 52 | 2200 | 128 | 129 | 130 | .681 | 482.5 | 70.8 | 70.4 | 78.7 | 78.6 | 519.2 | 72.0 | | 79.9 | 80.4 |
| 21 | 52 | 2350 | 123 | 119 | 130 | .723 | 514.1 | 72.1 | 72.4 | 79.4 | 79.7 | 544.0 | 74.8 | | 80.6 | 81.2 |
| 22 | 52 | 2300 | 116 | 116 | 118 | .704 | 527.7 | 72.1 | 72.7 | 79.7 | 80.0 | 532.3 | 71.8 | | 79.4 | 79.8 |

500 FT. LEVEL FLYOVER DATA

TABLE B-9

AIRCRAFT Baron 58P

TEST DATE 9-28-82

| AIRCRAFT TEST DATA | | | | | | | NOISE DATA SITE 1 | | | | | NOISE DATA SITE 2 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | GS (KTS) | | IAS (KTS) | | | | | | | | | | | |
| EVENT | % PWR | RPM | SITE 1 | SITE 2 | | $M_H$ | $ALT_T$ (ft) | $AL_{am}$ | $AL_{fc}$ | $SEL_{am}$ | $SEL_{fc}$ | $ALT_T$ (ft) | $AL_{am}$ | $AL_{fc}$ | $SEL_{am}$ | $SEL_{fc}$ |
| 9 | 67 | 2700 | 140 | 153 | 158 | .857 | [illegible] | 84.6 | 85.7 | 89.9 | 90.3 | 564.6 | 85.4 | 86.7 | 90.7 | 91.5 |
| 10 | 67 | 2650 | 160 | 152 | 160 | .844 | 530 | 84.7 | 85.3 | 89.0 | 89.4 | 597.1 | 82.5 | 84.3 | 85.9 | 87.1 |
| 11 | 67 | 2600 | 163 | 160 | 166 | .832 | 548.6 | 81.9 | 82.9 | 85.2 | 86.0 | 579.2 | 82.9 | 84.4 | 86.7 | 87.8 |
| 12 | 67 | 2550 | 165 | 168 | 172 | .820 | 543.9 | 81.6 | 82.5 | 85.5 | 86.2 | 585.4 | 79.0 | 80.6 | 84.8 | 86.2 |
| 13 | 67 | [illegible] | 164 | 161 | 169 | .804 | 538.4 | 79.7 | 80.5 | 85.2 | 85.0 | 553.5 | 79.3 | 80.4 | 85.3 | 86.1 |
| 14 | 67 | 2450 | 153 | 157 | 163 | .787 | 575.5 | 78.2 | 79.7 | 84.5 | 85.4 | 540.6 | 79.2 | 80.0 | 85.1 | 85.7 |
| 15 | 67 | 2400 | 176 | 164 | 166 | .774 | 527.4 | 78.8 | 79.4 | 84.5 | 85.2 | 558.4 | 77.6 | 78.8 | 84.2 | 85.1 |
| 16 | 67 | 2300 | 168 | 160 | 164 | .744 | 540.1 | 76.6 | 77.4 | 83.7 | 84.4 | 542.7 | 76.1 | 77.0 | 83.3 | 83.9 |
| 17 | 67 | 2200 | 162 | 161 | 164 | .715 | 501.1 | 76.2 | 76.2 | 83.5 | 83.5 | 523.4 | 75.0 | 75.5 | 83.3 | 83.6 |
| 18 | 67 | 2700 | 156 | 158 | 160 | .858 | 525.6 | 88.1 | 88.6 | 91.2 | 91.5 | 570.2 | 86.2 | 87.6 | 90.1 | 91.1 |
| 19 | 97 | 2600 | 180 | 190 | 194 | .846 | 565.1 | 83.5 | 84.8 | 87.8 | 88.6 | 546.4 | 85.5 | 86.4 | 88.9 | 89.6 |
| 22 | 97 | 2600 | 186 | 185 | 194 | .846 | 513.3 | 84.5 | 84.8 | 89.5 | 89.8 | 590.3 | 84.8 | 86.5 | 89.1 | 90.3 |

500 FT. LEVEL FLYOVER DATA

TABLE B-10 (CONT)

AIRCRAFT Baron 58P (CONT) TEST DATE 9-28-82

| AIRCRAFT TEST DATA | | | | | | | NOISE DATA SITE 1 | | | | | NOISE DATA SITE 2 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | GS (KTS) | | | | | | | | | | | | | |
| EVENT | % PWR | RPM | SITE 1 | SITE 2 | IAS (KTS) | $M_H$ | $ALT_T$ (ft) | $AL_{am}$ | $AL_{fc}$ | $SEL_{am}$ | $SEL_{fc}$ | $ALT_T$ (ft) | $AL_{am}$ | $AL_{fc}$ | $SEL_{am}$ | $SEL_{fc}$ |
| 20 | 75 | 2600 | 170 | 174 | 176 | .836 | 547.9 | 87.3 | 88.3 | 90.5 | 91.3 | 531.9 | 86.3 | 86.9 | 89.8 | 90.4 |
| 23 | 75 | 2600 | 172 | 171 | 176 | .836 | 503 | 84.2 | 84.3 | 89.1 | 89.2 | 557.2 | 83.6 | 84.7 | 88.0 | 88.9 |
| 25 | 75 | 2600 | 163 | 168 | 176 | .836 | 565.3 | 81.7 | 83.0 | 87.1 | 87.9 | 574.6 | 84.9 | 86.3 | 79.6 | 80.6 |
| 26 | 75 | 2600 | 161 | 157 | 176 | .836 | 591.1 | 83.3 | 85.0 | 89.0 | 90.1 | 698.9 | 81.3 | 84.8 | 86.5 | 88.8 |
| | | | | | | | | | | | | | | | | |
| 21 | 50 | 2600 | 139 | 138 | 145 | .823 | 551.2 | 79.8 | 80.8 | 85.5 | 86.2 | 577.3 | 81.9 | 83.4 | 86.6 | 87.7 |
| 24 | 50 | 2600 | 141 | 138 | 145 | .823 | 529.4 | 81.0 | 81.6 | 85.1 | 85.5 | 550 | 82.5 | 83.5 | 87.5 | 88.2 |

500 FT. LEVEL FLYOVER DATA

TABLE B-11

*Indicates Estimate

AIRCRAFT C- 425 Conquest-I

TEST DATE 10-26-82

| AIRCRAFT TEST DATA | | | | | | | NOISE DATA SITE 1 | | | | | NOISE DATA SITE 2 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | GS (KTS) | | | | | | | | | | | | | |
| EVENT | % PWR | RPM | SITE 1 | SITE 2 | IAS (KTS) | $M_H$ | $ALT_T$ (ft) | $AL_{am}$ | $AL_{fc}$ | $SEL_{am}$ | $SEL_{fc}$ | $ALT_T$ (ft) | $AL_{am}$ | $AL_{fc}$ | $SEL_{am}$ | $SEL_{fc}$ |
| 9 | 90 | 1650 | 85 | 185* | 210 | .6849 | 402 | 80.8 | 78.5 | 84.9 | 82.7 | 548 | 79.1 | 80.1 | 83.5 | 84.3 |
| 10 | 90 | 1750 | 175 | 175* | 200 | .7109 | 395 | 80.3 | 77.8 | 84.4 | 81.8 | 481 | 79.7 | 79.3 | 83.9 | 83.5 |
| 11 | 90 | 1750 | 180 | 180* | 205 | .7143 | 414 | 80.8 | 78.8 | 84.4 | 82.4 | 462 | 79.5 | 78.7 | 83.7 | 83.1 |
| 12 | 90 | 1850 | 175 | 175* | 200 | .7443 | 424 | 81.2 | 79.5 | 84.6 | 82.8 | 462 | 78.5 | 77.7 | 83.1 | 82.4 |
| 13 | 90 | 1850 | 175 | 175* | 200 | .7443 | 417 | 80.4 | 78.5 | 84.2 | 82.2 | 421 | 80.5 | 78.7 | 84.3 | 82.9 |
| 14 | 90 | 1900 | 182 | 182* | 207 | .7655 | 428 | 80.6 | 79.0 | 84.4 | 82.8 | 436 | 82.4 | 81.0 | 85.7 | 84.7 |
| 15 | 90 | 1900 | 182 | 182* | 207 | .7655 | 393 | 82.1 | 79.6 | 85.5 | 83.0 | 471 | 81.5 | 80.9 | 85.0 | 84.6 |
| 22 | 90 | 1875 | 180 | 180* | 205 | .7588 | 418 | 80.8 | 78.9 | 84.7 | 82.8 | 453 | 80.0 | 79.0 | 84.2 | 83.5 |
| 23 | 90 | 1875 | 180 | 180* | 205 | .7588 | 454 | 81.0 | 80.0 | 84.6 | 83.6 | 496 | 80.0 | 79.9 | 84.2 | 84.1 |
| | | | | | | | | | | | | | | | | |
| 20 | 100 | 1900 | 190 | 190* | 215 | .7705 | 421 | 81.9 | 80.1 | 85.8 | 84.0 | 491 | 82.9 | 82.7 | 86.1 | 86.0 |
| 21 | 100 | 1900 | 190 | 190* | 215 | .7705 | 434 | 83.8 | 82.3 | 85.8 | 84.3 | 501 | 82.4 | 83.4 | 85.9 | 85.9 |
| | | | | | | | | | | | | | | | | |
| 16 | 75 | 1900 | 165 | 165* | 190 | .7552 | 418 | 82.7 | 80.8 | 85.8 | 83.9 | 436 | 78.4 | 81.7 | 82.7 | 81.7 |
| 17 | 75 | 1900 | 165 | 165* | 190 | .7552 | 425 | 81.3 | 79.6 | 84.9 | 83.2 | 471 | 79.6 | 83.2 | 83.6 | 83.2 |

500 FT. LEVEL FLYOVER DATA

TABLE B-11 (CONT)

AIRCRAFT C-425 Conquest-I (CONT)

TEST DATE 10-26-82

| AIRCRAFT TEST DATA | | | | | | | NOISE DATA SITE 1 | | | | | NOISE DATA SITE 2 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | GS (KTS) | | | | | | | | | | | | | |
| EVENT | % PWR | RPM | SITE 1 | SITE 2 | IAS (KTS) | $M_H$ | $ALT_T$ (ft) | $AL_{am}$ | $AL_{fc}$ | $SEL_{am}$ | $SEL_{fc}$ | $ALT_T$ (ft) | $AL_{am}$ | $AL_{fc}$ | $SEL_{am}$ | $SEL_{fc}$ |
| 18 | 50 | 1900 | 145 | 145* | 170 | .7440 | 415 | 79.7 | 77.8 | 83.4 | 81.5 | 453 | 76.6 | 75.6 | 81.2 | 80.5 |
| 19 | 50 | 1900 | 145 | 145* | 170 | .7440 | 444 | 78.6 | 77.4 | 82.7 | 81.5 | 449 | 77.6 | 76.5 | 82.6 | 81.8 |

# APPENDIX C

# COCKPIT DATA

## Appendix C: Cockpit Data

This appendix contains various cockpit instrumentation readings logged by a cockpit observer. The readings were logged when the aircraft was approximately over the prime site. Due to the difficulty in seeing the ground from the cockpit during the takeoff operation, it was hard to determine when the aircraft was in fact directly over the site. This will account for the difference between test altitude ($ALT_T$) listed in Appendices A and B and the altitude listed in Appendix C.

TABLE C-1

COCKPIT DATA

AIRCRAFT C-180 TEST DATE 6-3-82

| EVENT NO. | EVENT TYPE | MANIFOLD PRESS. | TORQUE | PROP RPM | IAS (KTS) | HEADING (DEGREES) | ALTITUDE |
|---|---|---|---|---|---|---|---|
| 1 | Takeoff | 27.5 | N/A | 2550 | 78.3 | 180 | - |
| 2 | Takeoff | 27.5 | N/A | 2550 | 78.3 | 180 | - |
| 3 | Takeoff | 27.5 | N/A | 2550 | 78.3 | 180 | - |
| 4 | Takeoff | 27.5 | N/A | 2550 | 78.3 | 180 | - |
| 5 | Takeoff | 27.5 | N/A | 2550 | 78.3 | 180 | - |
| 6 | Takeoff | 27.5 | N/A | 2550 | 78.3 | 180 | - |
| 7 | Takeoff | 27.5 | N/A | 2550 | 78.3 | 180 | - |

TABLE C-2

COCKPIT DATA

AIRCRAFT C-170 TEST DATE 6-23-82

| EVENT NO. | EVENT TYPE | MANIFOLD PRESS. | TORQUE | PROP RPM | IAS (KTS) | HEADING (DEGREES) | ALTITUDE |
|---|---|---|---|---|---|---|---|
| 1 | Takeoff | – | N/A | 2375 | 85 | 360 | – |
| 2 | Takeoff | – | N/A | 2375 | 85 | 360 | – |
| 3 | Takeoff | – | N/A | 2375 | 90 | 360 | – |
| 4 | Takeoff | – | N/A | 2375 | 85 | 360 | – |
| 5 | Takeoff | – | N/A | 2375 | 85 | 360 | – |
| 6 | Takeoff | – | N/A | 2375 | 85 | 360 | – |
| 7 | Takeoff | – | N/A | 2375 | 85 | 360 | – |
| 8 | Takeoff | – | N/A | 2375 | 90 | 360 | – |
| 9 | Flyover | – | N/A | 2450 | 125 | 360 | – |
| 10 | Flyover | – | N/A | 2450 | 125 | 360 | – |
| 11 | Flyover | – | N/A | 2450 | 125 | 360 | – |
| 12 | Flyover | – | N/A | 2225 | 105 | 360 | – |
| 13 | Flyover | – | N/A | 2225 | 105 | 360 | – |
| 14 | Flyover | – | N/A | 2175 | 98 | 360 | – |
| 15 | Flyover | – | N/A | 1900 | 85 | 360 | – |
| 16 | Flyover | – | N/A | 1900 | 90 | 360 | – |
| 17 | Flyover | – | N/A | 1700 | 85 | 360 | – |
| 18 | Flyover | – | N/A | 2450 | 120 | 360 | – |
| 19 | Flyover | – | N/A | 2450 | 120 | 360 | – |
| 21 | Flyover | – | N/A | 2450 | 120 | 360 | – |
| 22 | Flyover | – | N/A | 2450 | 120 | 360 | – |
| 23 | Flyover | – | N/A | 2450 | 117 | 360 | – |
| 24 | Flyover | – | N/A | 2450 | 120 | 360 | – |

TABLE C-3

COCKPIT DATA

AIRCRAFT PA-28RT-201T Turbo Arrow IV

TEST DATE 7-13-82

| EVENT NO. | EVENT TYPE | MANIFOLD PRESS. | TORQUE | PROP RPM | IAS (KTS) | HEADING (DEGREES) | ALTITUDE |
|---|---|---|---|---|---|---|---|
| 1 | Takeoff | 41.0 | N/A | 2600 | 97 | 010 | - |
| 2 | Takeoff | 41.0 | N/A | 2600 | 97 | 010 | - |
| 3 | Takeoff | 41.0 | N/A | 2600 | 97 | 011 | - |
| 4 | Takeoff | 41.0 | N/A | 2600 | 97 | 010 | - |
| 5 | Takeoff | 41.0 | N/A | 2450 | 96 | 008 | - |
| 6 | Takeoff | 41.0 | N/A | 2600 | 96 | 009 | - |
| 7 | Takeoff | 41.0 | N/A | 2600 | 95 | 010 | - |
| 8 | Flyover | 26.0 | N/A | 2500 | 95 | - | - |
| 9 | Flyover | 26.0 | N/A | 2500 | 96 | 010 | - |
| 10 | Flyover | 26.8 | N/A | 2400 | 98 | 010 | - |
| 11 | Flyover | 26.8 | N/A | 2400 | 97 | 008 | - |
| 12 | Flyover | 27.7 | N/A | 2300 | 100 | 006 | - |
| 13 | Flyover | 27.7 | N/A | 2300 | 98 | 004 | - |
| 14 | Takeoff | 41.0 | N/A | 2600 | 96 | 010 | - |
| 15 | Takeoff | 40.0 | N/A | 2600 | 99 | 004 | - |
| 16 | Takeoff | 40.0 | N/A | 2600 | 98 | 010 | - |
| 17 | Takeoff | 41.0 | N/A | 2600 | 99 | 008 | - |

TABLE C-4

COCKPIT DATA

AIRCRAFT C-180

TEST DATE 7-20-82

| EVENT NO. | EVENT TYPE | MANIFOLD PRESS. | TORQUE | PROP RPM | IAS (KTS) | HEADING (DEGREES) | ALTITUDE |
|---|---|---|---|---|---|---|---|
| 1 | Flyover | 31.5 | N/A | 2575 | 138 | 005 | - |
| 2 | Flyover | 31.5 | N/A | 2575 | 138 | 185 | - |
| 3 | Flyover | 32.0 | N/A | 2575 | 140 | 005 | - |
| 4 | Flyover | 33.0 | N/A | 2500 | 142 | 185 | - |
| 5 | Flyover | 32.8 | N/A | 2500 | 140 | 005 | - |
| 6 | Flyover | 33.3 | N/A | 2450 | 142 | 185 | - |
| 7 | Flyover | 33.3 | N/A | 2450 | 140 | 005 | - |
| 8 | Flyover | 33.8 | N/A | 2400 | 142 | 185 | |
| 9 | Flyover | 33.8 | N/A | 2400 | 140 | 005 | - |
| 10 | Flyover | 41.0 | N/A | 2575 | 162 | 185 | - |
| 11 | Flyover | 41.0 | N/A | 2575 | 160 | 005 | - |
| 12 | Flyover | 40.5 | N/A | 2575 | 160 | 005 | - |
| 13 | Flyover | 26.8 | N/A | 2400 | 120 | 006 | - |
| 14 | Flyover | 26.8 | N/A | 2400 | 119 | 008 | - |
| 15 | Flyover | 26.8 | N/A | 2400 | 121 | 008 | - |
| 16 | Flyover | 27.7 | N/A | 2300 | 120 | 008 | - |
| 17 | Flyover | 27.5 | N/A | 2300 | 120 | 005 | - |
| 21 | Flyover | 27.0 | N/A | 2600 | 165 | - | - |
| 22 | Flyover | 27.0 | N/A | 2600 | 162 | - | - |
| 23 | Flyover | 27.0 | N/A | 2600 | 160 | - | - |
| 24 | Flyover | 27.0 | N/A | 2550 | 163 | - | - |
| 25 | Flyover | 22.0 | N/A | 2600 | 148 | 355 | - |
| 26 | Flyover | 22.0 | N/A | 2600 | 145 | 355 | - |

TABLE C-4 (CONT)

COCKPIT DATA

AIRCRAFT C-180 (CONT) TEST DATE 7-20-82

| EVENT NO. | EVENT TYPE | MANIFOLD PRESS. | TORQUE | PROP RPM | IAS (KTS) | HEADING (DEGREES) | ALTITUDE |
|---|---|---|---|---|---|---|---|
| 27 | Flyover | 22.0 | N/A | 2425 | 148 | 355 | - |
| 28 | Flyover | 23.0 | N/A | 2450 | 151 | 355 | - |
| 29 | Flyover | 23.0 | N/A | 2450 | 151 | 355 | - |
| 30 | Flyover | 23.0 | N/A | 2450 | 153 | 355 | - |
| 31 | Flyover | 16.8 | N/A | 2450 | 120 | 355 | - |
| 32 | Flyover | 16.8 | N/A | 2425 | 119 | 355 | - |
| 33 | Flyover | 17.1 | N/A | 2400 | 125 | 355 | - |
| 34 | Flyover | 17.5 | N/A | 2350 | 130 | 355 | - |
| 35 | Flyover | 17.9 | N/A | 2300 | 131 | 355 | - |
| 36 | Flyover | 18.9 | N/A | 2200 | 124 | 355 | - |
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TABLE C-5

COCKPIT DATA

AIRCRAFT PA-38-112 Tomahawk

TEST DATE 8-10-82

| EVENT NO. | EVENT TYPE | MANIFOLD PRESS. | TORQUE | PROP RPM | IAS (KTS) | HEADING (DEGREES) | ALTITUDE |
|---|---|---|---|---|---|---|---|
| 1 | Takeoff | - | N/A | 2350 | 70 | 360 | - |
| 2 | Takeoff | - | N/A | 2350 | 70 | 350 | - |
| 3 | Takeoff | - | N/A | 2350 | 70 | 350 | - |
| 4 | Takeoff | - | N/A | 2350 | 70 | 350 | - |
| 5 | Takeoff | - | N/A | 2350 | 70 | 352 | - |
| 6 | Takeoff | - | N/A | 2350 | 69 | 340 | - |
| 7 | Takeoff | - | N/A | 2350 | 70 | [illegible] | - |
| 8 | Takeoff | - | N/A | 2350 | 72 | 345 | - |
| 9 | Takeoff | - | N/A | 2500 | 95 | 345 | - |
| 10 | Takeoff | - | N/A | 2500 | 95 | 340 | - |
| 11 | Takeoff | - | N/A | 2500 | 90 | 340 | - |
| 12 | Takeoff | - | N/A | 2550 | 98 | - | - |
| 13 | Takeoff | - | N/A | 2600 | 110 | 345 | - |
| 14 | Takeoff | - | N/A | 2600 | 105 | 345 | - |
| 15 | Takeoff | - | N/A | 2600 | 105 | 345 | - |
| 16 | Flyover | - | N/A | 2410 | 98 | 360 | - |
| 17 | Flyover | - | N/A | 2410 | 100 | 355 | - |
| 18 | Flyover | - | N/A | 2350 | 95 | 360 | - |
| 19 | Flyover | - | N/A | 2350 | 97 | 355 | - |
| 20 | Flyover | - | N/A | 2300 | 90 | 350 | - |
| 21 | Flyover | - | N/A | 2300 | 90 | 355 | - |
| 22 | Flyover | - | N/A | 2170 | 85 | 355 | - |
| 23 | Flyover | - | N/A | 2170 | 85 | 350 | - |

TABLE C-6

COCKPIT DATA

AIRCRAFT King Air 200

TEST DATE 8-31-82

| EVENT NO. | EVENT TYPE | MANIFOLD PRESS. | TORQUE | PROP RPM | IAS (KTS) | HEADING (DEGREES) | ALTITUDE (MSL) |
|---|---|---|---|---|---|---|---|
| 1 | Takeoff | N/A | 2230 | 2000 | 126 | 010 | 1500 |
| 2 | Takeoff | N/A | 2230 | 2000 | 126 | 010 | 1000 |
| 3 | Takeoff | N/A | 2230 | 2000 | 126 | 010 | 1100 |
| 4 | Takeoff | N/A | 2230 | 2000 | 126 | 010 | 1200 |
| 5 | Takeoff | N/A | 2230 | 2000 | 126 | 010 | 1200 |
| 6 | Takeoff | N/A | 2230 | 2000 | 126 | 010 | 1100 |
| 7 | Takeoff | N/A | 2230 | 2000 | 126 | 010 | 1100 |
| 8 | Flyover | N/A | 2230 | 1700 | 235 | 010 | - |
| 9 | Flyover | N/A | 2165 | 1750 | 235 | 010 | 800 |
| 10 | Flyover | N/A | 2105 | 1800 | 230 | 010 | 800 |
| 11 | Flyover | N/A | 2050 | 1850 | 232 | 010 | 800 |
| 12 | Flyover | N/A | 1995 | 1900 | 232 | 010 | 800 |
| 13 | Flyover | N/A | 1945 | 1950 | 231 | 010 | 800 |
| 14 | Flyover | N/A | 1895 | 2000 | 234 | 010 | 800 |
| 15 | Flyover | N/A | 1995 | 1900 | 233 | 010 | 800 |
| 16 | Flyover | N/A | 1945 | 1950 | 232 | 010 | 800 |
| 17 | Flyover | N/A | 1895 | 2000 | 233 | 010 | 800 |
| 18 | Flyover | N/A | 2230 | 1900 | 238 | 010 | 800 |
| 19 | Flyover | N/A | 2230 | 1900 | 240 | 010 | 800 |
| 20 | Flyover | N/A | 2230 | 1900 | 239 | 010 | 800 |
| 21 | Flyover | N/A | 2230 | 1900 | 239 | 010 | 800 |
| 22 | Flyover | N/A | 1672 | 1900 | 214 | 010 | 800 |
| 23 | Flyover | N/A | 1672 | 1900 | 214 | 010 | 800 |

TABLE C-6 (CONT)

COCKPIT DATA

AIRCRAFT King Air 200 (CONT)

TEST DATE 8-31-82

| EVENT NO. | EVENT TYPE | MANIFOLD PRESS. | TORQUE | PROP RPM | IAS (KTS) | HEADING (DEGREES) | ALTITUDE (MSL) |
|---|---|---|---|---|---|---|---|
| 24 | Flyover | N/A | 1672 | 1900 | 215 | 010 | 800 |
| 25 | Flyover | N/A | 1672 | 1900 | 214 | 010 | 800 |
| 26 | Flyover | N/A | 1115 | 1900 | 195 | 010 | 800 |
| 27 | Flyover | N/A | 1115 | 1900 | 194 | 010 | 800 |
| 28 | Flyover | N/A | 1115 | 1900 | 194 | 010 | 800 |
| 29 | Flyover | N/A | 1115 | 1900 | 194 | 010 | 800 |

TABLE C-7

COCKPIT DATA

AIRCRAFT PA-42 Cheyenne

TEST DATE 9-8-82

| EVENT NO. | EVENT TYPE | MANIFOLD PRESS. | TORQUE | PROP RPM | IAS (KTS) | HEADING (DEGREES) | ALTITUDE |
|---|---|---|---|---|---|---|---|
| 1 | Flyover | N/A | 1895 | 2000 | 240 | 010 | - |
| 2 | Flyover | N/A | 1945 | 1950 | 236 | 010 | - |
| 3 | Flyover | N/A | 1995 | 1900 | 236 | 010 | - |
| 4 | Flyover | N/A | 2050 | 1850 | 236 | 010 | - |
| 5 | Flyover | N/A | 2105 | 1800 | 236 | 010 | - |
| 6 | Flyover | N/A | 2105 | 1750 | 230 | 010 | - |
| 7 | Flyover | N/A | 2165 | 1700 | 230 | 010 | - |
| 8 | Flyover | N/A | 2230 | 1850 | 231 | 010 | - |
| 9 | Flyover | N/A | 2050 | 1900 | 231 | 010 | - |
| 10 | Flyover | N/A | 1995 | 1900 | 210 | 010 | - |
| 11 | Flyover | N/A | 1995 | 1900 | 210 | 010 | - |
| 12 | Flyover | N/A | 1995 | 1900 | 210 | 010 | - |
| 13 | Flyover | N/A | 1995 | 1900 | 210 | 010 | - |
| 14 | Flyover | N/A | 1995 | 1900 | 210 | 010 | - |
| 15 | Flyover | N/A | 1493 | 1900 | 209 | 010 | - |
| 16 | Flyover | N/A | 1493 | 1900 | 210 | 010 | - |
| 17 | Flyover | N/A | 1493 | 1900 | 205 | 010 | - |
| 18 | Flyover | N/A | 1493 | 1900 | 203 | 010 | - |
| 19 | Flyover | N/A | 1493 | 1900 | 205 | 010 | - |
| 20 | Flyover | N/A | 995 | 1900 | 183 | 010 | - |
| 21 | Flyover | N/A | 995 | 1900 | 183 | 010 | - |
| 22 | Takeoff | N/A | 1895 | 2000 | 115 | 010 | - |
| 23 | Takeoff | N/A | 1895 | 2000 | 115 | 010 | - |

TABLE C-7 (CONT)

COCKPIT DATA

AIRCRAFT PA-42 Cheyenne (CONT) TEST DATE 9-8-82

| EVENT NO. | EVENT TYPE | MANIFOLD PRESS. | TORQUE | PROP RPM | IAS (KTS) | HEADING (DEGREES) | ALTITUDE |
|---|---|---|---|---|---|---|---|
| 24 | Takeoff | N/A | 1895 | 2000 | 115 | 010 | - |
| 25 | Takeoff | N/A | 1895 | 2000 | 115 | 010 | - |
| 26 | Takeoff | N/A | 1895 | 2000 | 115 | 010 | - |
| 27 | Takeoff | N/A | 1895 | 2000 | 115 | 010 | - |
| 28 | Takeoff | N/A | 995 | 1900 | 170 | 010 | - |
| 29 | Takeoff | N/A | 995 | 1900 | 171 | 010 | - |

TABLE C-8

COCKPIT DATA

AIRCRAFT C-414 Chancellor

TEST DATE 9-14-82

| EVENT NO. | EVENT TYPE | MANIFOLD PRESS. | TORQUE | PROP RPM | IAS (KTS) | HEADING (DEGREES) | ALTITUDE |
|---|---|---|---|---|---|---|---|
| 1 | Flyover | 33.8 | N/A | 2700 | 170 | 180 | - |
| 2 | Flyover | 34.3 | N/A | 2650 | 170 | 175 | - |
| 3 | Flyover | 34.8 | N/A | 2600 | 176 | 180 | - |
| 4 | Flyover | 35.5 | N/A | 2550 | 176 | 185 | - |
| 5 | Flyover | 27.0 | N/A | 2700 | 145 | 179 | - |
| 6 | Flyover | 28.5 | N/A | 2600 | 154 | 178 | - |
| 7 | Flyover | 30.0 | N/A | 2500 | 160 | 180 | - |
| 8 | Flyover | 30.8 | N/A | 2450 | 160 | 187 | - |
| 9 | Flyover | 31.5 | N/A | 2400 | 162 | 185 | - |
| 10 | Flyover | 32.9 | N/A | 2300 | 162 | 185 | - |
| 11 | Flyover | 33.7 | N/A | 2250 | 163 | 185 | - |
| 12 | Flyover | 21.7 | N/A | 2450 | 120 | 185 | |
| 13 | Flyover | 22.2 | N/A | 2400 | 120 | 190 | - |
| 14 | Flyover | 22.6 | N/A | 2350 | 118 | 190 | - |
| 15 | Flyover | 23.1 | N/A | 2300 | 120 | 181 | - |
| 16 | Flyover | 23.5 | N/A | 2250 | 118 | 181 | - |
| 17 | Flyover | 24.3 | N/A | 2200 | 130 | 182 | - |
| 18 | Flyover | 33.8 | N/A | 2700 | 175 | 185 | - |
| 19 | Flyover | 27.0 | N/A | 2700 | - | - | - |
| 20 | Flyover | 30.0 | N/A | 2500 | 162 | 185 | - |
| 21 | Flyover | 22.6 | N/A | 2350 | 130 | 185 | - |
| 22 | Flyover | 23.1 | N/A | 2300 | 118 | 187 | - |
| 23 | Takeoff | - | N/A | - | 110 | 187 | - |

TABLE C-8 (CONT)

COCKPIT DATA

AIRCRAFT C-414 Chancellor (CONT) TEST DATE 9-14-82

| EVENT NO. | EVENT TYPE | MANIFOLD PRESS. | TORQUE | PROP RPM | IAS (KTS) | HEADING (DEGREES) | ALTITUDE |
|---|---|---|---|---|---|---|---|
| 24 | Takeoff | - | N/A | - | 110 | 187 | - |
| 25 | Takeoff | - | N/A | - | 115 | 187 | - |
| 26 | Takeoff | - | N/A | - | 110 | 187 | - |
| 27 | Takeoff | - | N/A | - | 112 | 187 | - |
| 28 | Takeoff | - | N/A | - | 110 | 187 | - |

TABLE C-9

COCKPIT DATA

AIRCRAFT B58-P Baron TEST DATE 9-28-82

| EVENT NO. | EVENT TYPE | MANIFOLD PRESS. | TORQUE | PROP RPM | IAS (KTS) | HEADING (DEGREES) | ALTITUDE (AGL) |
|---|---|---|---|---|---|---|---|
| 1 | Takeoff | 39.5 | N/A | 2700 | 115 | 005 | - |
| 2 | Takeoff | 39.5 | N/A | 2700 | 115 | 005 | 1100 |
| 3 | Takeoff | 39.5 | N/A | 2700 | 113 | 005 | 1100 |
| 4 | Takeoff | 39.5 | N/A | 2700 | 115 | 010 | 1000 |
| 5 | Takeoff | 39.5 | N/A | 2700 | 115 | 010 | 1200 |
| 6 | Takeoff | 39.5 | N/A | 2700 | 115 | 010 | 1000 |
| 7 | Takeoff | 39.5 | N/A | 2700 | 115 | 010 | 1100 |
| 8 | Takeoff | 39.5 | N/A | 2700 | 115 | 010 | 1100 |
| 9 | Flyover | 27.2 | N/A | 2700 | 158 | 010 | 500 |
| 10 | Flyover | 27.5 | N/A | 2700 | 160 | 010 | 500 |
| 11 | Flyover | 27.9 | N/A | 2650 | 166 | 010 | 500 |
| 12 | Flyover | 28.3 | N/A | 2600 | 172 | 010 | 500 |
| 13 | Flyover | 28.7 | N/A | 2550 | 169 | 010 | 500 |
| 14 | Flyover | 29.2 | N/A | 2500 | 163 | 010 | 500 |
| 15 | Flyover | 29.7 | N/A | 2450 | 166 | 010 | 500 |
| 16 | Flyover | 31.0 | N/A | 2400 | 164 | 010 | 500 |
| 17 | Flyover | 33.0 | N/A | 2300 | 164 | 010 | 500 |
| 18 | Flyover | 27.2 | N/A | 2200 | 160 | 010 | 500 |
| 19 | Flyover | 29.5 | N/A | 2700 | 194 | 010 | 500 |
| 20 | Flyover | 31.8 | N/A | 2600 | 176 | 010 | 500 |
| 21 | Flyover | 23.5 | N/A | 2600 | 145 | 010 | 500 |
| 22 | Flyover | 39.5 | N/A | 2600 | 194 | 010 | 500 |
| 23 | Flyover | 31.8 | N/A | 2600 | 176 | 010 | 500 |

TABLE C-9 (CONT)

COCKPIT DATA

AIRCRAFT B58-P Baron (CONT)

TEST DATE 9-28-82

| EVENT NO. | EVENT TYPE | MANIFOLD PRESS. | TORQUE | PROP RPM | IAS (KTS) | HEADING (DEGREES) | ALTITUDE (AGL) |
|---|---|---|---|---|---|---|---|
| 24 | Flyover | 23.5 | N/A | 2600 | 145 | 010 | 500 |
| 25 | Flyover | 31.8 | N/A | 2600 | 176 | 010 | 500 |
| 26 | Flyover | 31.8 | N/A | 2600 | 176 | 010 | 500 |

*NOTE: ACTUAL PROPELLER SPEED = 182 PLUS INDICATED VALUE

TABLE C-10

COCKPIT DATA

AIRCRAFT C-210 Centurion

TEST DATE 10-5-82

| EVENT NO. | EVENT TYPE | MANIFOLD PRESS. | TORQUE | PROP RPM | IAS (KTS) | HEADING (DEGREES) | ALTITUDE (MSL) |
|---|---|---|---|---|---|---|---|
| 1 | Takeoff | N/A | - | 2700 | 98 | 180 | 1100 |
| 2 | Takeoff | N/A | 2700 | 2700 | 95 | 185 | 1200 |
| 3 | Takeoff | N/A | 2700 | 2700 | 95 | 175 | 1300 |
| 4 | Takeoff | N/A | 2700 | 2700 | 97 | 185 | 1200 |
| 5 | Takeoff | N/A | 2700 | 2700 | 98 | 180 | 1300 |
| 6 | Takeoff | N/A | 2700 | 2700 | 97 | 180 | 1300 |
| 7 | Takeoff | N/A | 2700 | 2700 | 97 | 180 | 1350 |

TABLE C-11

COCKPIT DATA

AIRCRAFT C-182 Skylane

TEST DATE 10-5-82

| EVENT NO. | EVENT TYPE | MANIFOLD PRESS. | TORQUE | PROP RPM | IAS (KTS) | HEADING (DEGREES) | ALTITUDE (MSL) |
|---|---|---|---|---|---|---|---|
| 14 | Takeoff | 30.0 | N/A | 2400 | 92 | 180 | 1250 |
| 15 | Takeoff | 31.0 | N/A | 2400 | 92 | 182 | 1200 |
| 16 | Takeoff | 31.0 | N/A | 2400 | 91 | 182 | 1200 |
| 17 | Takeoff | 31.0 | N/A | 2400 | 90 | 182 | 1100 |
| 18 | Takeoff | 31.0 | N/A | 2400 | 89 | 182 | 1100 |
| 19 | Takeoff | 31.0 | N/A | 2400 | 90 | 182 | 1150 |

TABLE C-12

COCKPIT DATA

AIRCRAFT C-172 Skyhawk

TEST DATE 10-5-82

| EVENT NO. | EVENT TYPE | MANIFOLD PRESS. | TORQUE | PROP RPM | IAS (KTS) | HEADING (DEGREES) | ALTITUDE (MSL) |
|---|---|---|---|---|---|---|---|
| 26 | Takeoff | - | N/A | 2300 | 75 | 180 | 900 |
| 27 | Takeoff | - | N/A | 2300 | 75 | 180 | 900 |
| 28 | Takeoff | | N/A | 2300 | 75 | 180 | 900 |
| 29 | Takeoff | - | N/A | 2300 | 75 | 180 | 900 |
| 30 | Takeoff | - | N/A | 2300 | 75 | 180 | 900 |
| 31 | Takeoff | - | N/A | 2300 | 75 | 180 | 900 |
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TABLE C-13

COCKPIT DATA

AIRCRAFT Merlin 227-AT

TEST DATE 10-19-82

| EVENT NO. | EVENT TYPE | MANIFOLD PRESS. | TORQUE | PROP RPM | IAS (KTS) | HEADING (DEGREES) | ALTITUDE (AGL) |
|---|---|---|---|---|---|---|---|
| 2 | Takeoff | N/A | 100% | 100% | 147 | 180 | 1300 |
| 3 | Takeoff | N/A | 100% | 100% | 147 | 180 | 1200 |
| 4 | Takeoff | N/A | 100% | 100% | 147 | 180 | 1200 |
| 5 | Takeoff | N/A | 100% | 100% | 147 | 180 | 1300 |
| 6 | Takeoff | N/A | 100% | 100% | 147 | 180 | 1300 |
| 7 | Takeoff | N/A | 100% | 100% | 147 | 180 | 1300 |

TABLE C-14

COCKPIT DATA

AIRCRAFT Gulfstream Commander 900 TEST DATE 10-19-82

| EVENT NO. | EVENT TYPE | MANIFOLD PRESS. | TORQUE | PROP RPM | IAS (KTS) | HEADING (DEGREES) | ALTITUDE (MSL) |
|---|---|---|---|---|---|---|---|
| 15 | Takeoff | N/A | 97.5% | 100% | 135 | 180 | - |
| 16 | Takeoff | N/A | 97.5% | 100% | 135 | 185 | 1500 |
| 17 | Takeoff | N/A | 97.5% | 100% | 135 | 185 | 1700 |
| 18 | Takeoff | N/A | 97.5% | 100% | 135 | 185 | 1900 |
| 19 | Takeoff | N/A | 97.5% | 100% | 135 | 185 | 2000 |
| 20 | Takeoff | N/A | 97.5% | 100% | 135 | 185 | 2200 |

TABLE C-15

COCKPIT DATA

AIRCRAFT Beech Duchess

TEST DATE 10-19-82

| EVENT NO. | EVENT TYPE | MANIFOLD PRESS. | TORQUE | PROP RPM | IAS (KTS) | HEADING (DEGREES) | ALTITUDE (MSL) |
|---|---|---|---|---|---|---|---|
| 29 | Takeoff | 29.0 | N/A | 2700 | 97 | 185 | - |
| 30 | Takeoff | 29.0 | N/A | 2700 | 97 | 185 | 1500 |
| 31 | Takeoff | 29.0 | N/A | 2700 | 98 | 180 | 1600 |
| 32 | Takeoff | 29.0 | N/A | 2700 | 97 | 180 | 1500 |
| 33 | Takeoff | 29.0 | N/A | 2700 | 97 | 180 | 1600 |
| 34 | Takeoff | 29.0 | N/A | 2700 | 96 | 180 | 1800 |
| 35 | Takeoff | 29.0 | N/A | 2700 | 97 | 179 | 1700 |

TABLE C-16

COCKPIT DATA

AIRCRAFT Piper Navajo 350

TEST DATE 10-20-82

| EVENT NO. | EVENT TYPE | MANIFOLD PRESS. | TORQUE | PROP RPM | IAS (KTS) | HEADING (DEGREES) | ALTITUDE |
|---|---|---|---|---|---|---|---|
| 1 | Takeoff | 41.0 | N/A | 2525 | 106 | - | - |
| 2 | Takeoff | 41.0 | N/A | 2525 | 101 | - | - |
| 3 | Takeoff | 41.0 | N/A | 2525 | 101 | - | - |
| 4 | Takeoff | 41.0 | N/A | 2525 | 101 | - | - |
| 5 | Takeoff | 41.0 | N/A | 2525 | 100 | - | - |
| 6 | Takeoff | 41.0 | N/A | 2525 | 103 | - | - |
| 7 | Takoeff | 41.0 | N/A | 2525 | 101 | - | - |
| 8 | Takeoff | 41.0 | N/A | 2525 | 101 | - | - |

TABLE C-17

COCKPIT DATA

AIRCRAFT PA28-181 Archer II

TEST DATE 10-20-82

| EVENT NO. | EVENT TYPE | MANIFOLD PRESS. | TORQUE | PROP RPM | IAS (KTS) | HEADING (DEGREES) | ALTITUDE |
|---|---|---|---|---|---|---|---|
| 16 | Takeoff | - | N/A | 2350 | 76 | - | - |
| 17 | Takeoff | - | N/A | 2375 | 76 | - | - |
| 18 | Takeoff | - | N/A | 2350 | 76 | - | - |
| 19 | Takeoff | - | N/A | 2350 | 80 | - | - |
| 20 | Takeoff | - | N/A | 2350 | 77 | - | - |
| 21 | Takeoff | - | N/A | 2350 | 76 | - | - |

TABLE C-18

COCKPIT DATA

AIRCRAFT Beech Bonanza-36

TEST DATE 10-20-82

| EVENT NO. | EVENT TYPE | MANIFOLD PRESS. | TORQUE | PROP RPM | IAS (KTS) | HEADING (DEGREES) | ALTITUDE (AGL) |
|---|---|---|---|---|---|---|---|
| 30 | Takeoff | 29.0 | N/A | 2700 | 97 | 185 | 1300 |
| 31 | Takeoff | 28.5 | N/A | 2700 | 98 | 180 | 1300 |
| 32 | Takeoff | 28.0 | N/A | 2700 | 100 | 180 | 1300 |
| 33 | Takeoff | 28.0 | N/A | 2700 | 97 | 180 | 1300 |
| 34 | Takeoff | 28.0 | N/A | 2700 | 96 | 180 | 1400 |
| 35 | Takeoff | 28.0 | N/A | 2700 | 98 | 182 | 1400 |
| 36 | Takeoff | 28.5 | N/A | 2700 | 97 | 183 | 1400 |

TABLE C-19

COCKPIT DATA

AIRCRAFT C-425 Conquest-I TEST DATE 10-26-82

| EVENT NO. | EVENT TYPE | MANIFOLD PRESS. | TORQUE | PROP RPM | IAS (KTS) | HEADING (DEGREES) | ALTITUDE (MSL) |
|---|---|---|---|---|---|---|---|
| 1 | Takeoff | N/A | 1244 | 1900 | 115 | 360 | 1500 |
| 2 | Takeoff | N/A | 1244 | 1900 | 119 | 005 | 1800 |
| 3 | Takeoff | N/A | 1244 | 1900 | 115 | 010 | 1600 |
| 4 | Takeoff | N/A | 1244 | 1900 | 116 | 010 | 1800 |
| 5 | Takeoff | N/A | 1244 | 1900 | 115 | 010 | 1500 |
| 6 | Takeoff | N/A | 1244 | 1900 | 117 | 012 | 1600 |
| 7 | Takeoff | N/A | 1244 | 1900 | 118 | 010 | 1650 |

# APPENDIX D

# METEOROLOGICAL DATA

## Appendix D: Meteorological Data

### Surface

Surface temperature, relative humidity, and wind data were acquired in the vicinity of the noise measurement array during each test.

### Upper Air

On certain test days upper air meteorological data were reported as available from the National Weather Service Radiosonde Launch facility at nearby Sterling Park, Virginia (approx 3 miles away).

TABLE D-1

METEOROLOGICAL DATA

AIRCRAFT C-180

TEST DATE 6-3-82

| | SURFACE | | | | UPPER AIR | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | WIND | | | | | WIND | |
| TIME | TEMP (°F) | HUMIDITY (%) | SPEED (KTS) | DIRECTION | HT. ABOVE GND (FT.) | TEMP (°F) | HUMIDITY (%) | SPEED (KTS) | DIRECTION |
| 9:56 | 77 | 64 | 13 | 150 | | | | | |
| 10:15 | 77 | 60 | 13 | 150 | | | | | |
| 10:30 | 78 | 56 | 12 | 180 | | | | | |
| 10:45 | 77 | 58 | 13 | 160 | | | | | |
| 10:57 | 77 | 60 | 12 | 160 | | | | | |
| 11:17 | 76 | 62 | 12 | 170 | | | | | |
| 11:31 | 78 | 58 | 11 | 150 | | | | | |
| 11:46 | 77 | 58 | 12 | 140 | | | | | |
| 11:55 | 76 | 58 | 12 | 140 | | | | | |
| 12:14 | 80 | 54 | 13 | 140 | | | | | |
| 12:31 | 80 | 54 | 14 | 170 | | | | | |
| 12:46 | 78 | 54 | 16 | 170 | | | | | |
| 12:54 | 79 | 52 | 14 | 140 | | | | | |

TABLE D-2

METEOROLOGICAL DATA

AIRCRAFT C-170 TEST DATE 6-23-82

| | SURFACE | | | | UPPER AIR | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | WIND | | | | | WIND | |
| TIME | TEMP (°F) | HUMIDITY (%) | SPEED (KTS) | DIRECTION | HT. ABOVE GND (FT.) | TEMP (°F) | HUMIDITY (%) | SPEED (KTS) | DIRECTION |
| 5:53 | 61 | 84 | 3 | 340 | | | | | |
| 6:53 | 65 | 78 | 8 | 300 | | | | | |
| 7:54 | 68 | 70 | 7 | 300 | | | | | |
| 8:51 | 71 | 61 | 9 | 300 | | | | | |
| 9:52 | 73 | 57 | 8 | 310 | | | | | |
| 10:53 | 75 | 52 | 8 | 310 | | | | | |
| 11:53 | 76 | 48 | 5 | 330 | | | | | |
| 12:15 | 77 | 60 | - | - | | | | | |

TABLE D-3

METEOROLOGICAL DATA

AIRCRAFT PA-28RT-201T Turbo Arrow IV

TEST DATE 7-13-82

| | SURFACE | | | | UPPER AIR | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | WIND | | | | | WIND | |
| TIME | TEMP (°F) | HUMIDITY (%) | SPEED (KTS) | DIRECTION | HT. ABOVE GND (FT.) | TEMP (°F) | HUMIDITY (%) | SPEED (KTS) | DIRECTION |
| | | | | | 0 | 68 | 91 | 3 | 340 |
| | | | | | 246 | 71 | 79 | - | - |
| | | | | | 709 | 75 | 59 | - | - |
| | | | | | 910 | - | - | 10 | 013 |

TABLE D-4

METEOROLOGICAL DATA

AIRCRAFT C-180 TEST DATE 7-20-82

| | SURFACE | | | | UPPER AIR | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | WIND | | | | | WIND | |
| TIME | TEMP (°F) | HUMIDITY (%) | SPEED (KTS) | DIRECTION | HT. ABOVE GND (FT.) | TEMP (°F) | HUMIDITY (%) | SPEED (KTS) | DIRECTION |
| 5:30 | 71 | 97 | 2 | 100 | 0 | 70 | 94 | 0 | 230 |
| 5:44 | 71 | 97 | 0 | 000 | 269 | 71 | 93 | - | - |
| 5:55 | 71 | 97 | 0 | 000 | 620 | 73 | 86 | - | - |
| 6:13 | 71 | 100 | 2 | 230 | 1075 | - | - | 10 | 307 |
| 6:27 | 71 | 100 | 0 | 000 | 1874 | 70 | 83 | - | - |
| 6:45 | 72 | 97 | 0 | 000 | | | | | |
| 6:54 | 72 | 97 | 0 | 000 | | | | | |
| 7:15 | 73 | 100 | 4 | 310 | | | | | |
| 7:30 | 74 | 97 | 4 | 300 | | | | | |
| 7:46 | 74 | 97 | 4 | 280 | | | | | |
| 7:55 | 75 | 97 | 4 | 270 | | | | | |
| 8:19 | 77 | 94 | 4 | 280 | | | | | |
| 8:32 | 77 | 94 | 6 | 300 | | | | | |
| 8:45 | 77 | 90 | 5 | 310 | | | | | |
| 8:57 | 77 | 90 | 6 | 310 | | | | | |
| 9:15 | 78 | 88 | 7 | 290 | | | | | |
| 9:35 | 82 | 82 | 8 | 300 | | | | | |
| 9:52 | 82 | 85 | 9 | 310 | | | | | |

TABLE D-5

METEOROLOGICAL DATA

TEST DATE 8-10-82

AIRCRAFT PA-38-112 Tomahawk

| | SURFACE | | | | UPPER AIR | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | WIND | | | | | WIND | |
| TIME | TEMP (°F) | HUMIDITY (%) | SPEED (KTS) | DIRECTION | HT. ABOVE GND (FT.) | TEMP (°F) | HUMIDITY (%) | SPEED (KTS) | DIRECTION |
| 5:39 | 71 | 90 | 0 | 0 | 0 | 68 | 98 | 0 | 200 |
| 5:53 | 71 | 90 | 0 | 0 | 154 | 70 | 100 | - | - |
| 6:07 | - | - | 0 | 0 | 499 | 71 | 94 | - | - |
| 6:22 | 72 | 97 | 3 | 120 | 761 | 74 | 82 | - | - |
| 6:41 | - | - | 3 | 210 | 939 | - | - | 13 | 289 |
| 6:55 | 72 | 97 | 0 | 0 | | | | | |
| 7:10 | 74 | 90 | 3 | 250 | | | | | |
| 7:27 | 77 | 87 | 6 | 290 | | | | | |
| 7:50 | 79 | 88 | 6 | 290 | | | | | |
| 8:06 | 80 | 85 | 7 | 029 | | | | | |
| 8:22 | 81 | 79 | 8 | 030 | | | | | |
| 8:37 | 82 | 72 | 8 | 030 | | | | | |
| 8:52 | 83 | 65 | 8 | 029 | | | | | |
| 9:10 | 83 | 63 | 9 | 027 | | | | | |
| 9:25 | 84 | 59 | 8 | 028 | | | | | |
| 9:53 | 84 | 57 | 9 | 031 | | | | | |
| 10:53 | 86 | 48 | 10 | 031 | | | | | |

TABLE D-6

METEOROLOGICAL DATA

AIRCRAFT King Air 200 TEST DATE 8-31-82

| | SURFACE | | | | UPPER AIR | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | WIND | | | | | WIND | |
| TIME | TEMP (°F) | HUMIDITY (%) | SPEED (KTS) | DIRECTION | HT. ABOVE GND (FT.) | TEMP (°F) | HUMIDITY (%) | SPEED (KTS) | DIRECTION |
| 6:45 | 64 | 90 | 4 | 160 | 0 | 62.1 | 97 | 3 | 170 |
| 6:53 | 64 | 90 | 5 | 190 | 345 | 62.9 | 97 | - | - |
| 7:15 | 65 | 90 | 4 | 180 | 1060 | - | 97 | 13 | 228 |
| 7:30 | 66 | 91 | 4 | 180 | | | | | |
| 7:53 | 67 | [illegible] | 5 | 180 | | | | | |
| 8:15 | 68 | 90 | 6 | 170 | | | | | |
| 8:30 | 69 | 87 | 7 | 150 | | | | | |
| 8:43 | 70 | 84 | 7 | 170 | | | | | |
| 8:53 | 71 | 87 | 8 | 180 | | | | | |

TABLE D-7

METEOROLOGICAL DATA

TEST DATE 9-8-82

AIRCRAFT PA-42 Cheyenne

| | SURFACE | | | | UPPER AIR | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | WIND | | | | | WIND | |
| TIME | TEMP (°F) | HUMIDITY (%) | SPEED (KTS) | DIRECTION | HT. ABOVE GND (FT.) | TEMP (°F) | HUMIDITY (%) | SPEED (KTS) | DIRECTION |
| 6:46 | 66 | 84 | 0 | 0 | 0 | 65 | 84 | 6 | 140 |
| 6:54 | 66 | 84 | 4 | 270 | 407 | 63 | 87 | - | - |
| 7:05 | 66 | 84 | 0 | 0 | 903 | - | - | 10 | 142 |
| 7:20 | 66 | 84 | 3 | 270 | 1005 | 60 | 93 | - | - |
| 7:47 | 66 | 84 | 3 | 260 | | | | | |
| 7:52 | 66 | 84 | 4 | 260 | | | | | |
| 8:20 | 66 | 84 | 0 | 0 | | | | | |
| 8:53 | 70 | 78 | 0 | 0 | | | | | |
| 12:53 | 70 | 78 | 4 | 180 | | | | | |
| 1:53 | 70 | 78 | 6 | 140 | | | | | |
| 2:53 | 70 | 78 | 4 | 140 | | | | | |
| 3:53 | 70 | 78 | 4 | 150 | | | | | |

TABLE D-8

METEOROLOGICAL DATA

AIRCRAFT C-414 Chancellor

TEST DATE 9-14-82

| | SURFACE | | | | UPPER AIR | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | WIND | | | | | WIND | |
| TIME | TEMP (°F) | HUMIDITY (%) | SPEED (KTS) | DIRECTION | HT. ABOVE GND (FT.) | TEMP (°F) | HUMIDITY (%) | SPEED (KTS) | DIRECTION |
| 12:53 | 84 | 61 | 5 | 160 | | | | | |
| 1:31 | 84 | - | 4 | 120 | | | | | |
| 1:54 | 84 | 59 | 5 | 130 | | | | | |
| 2:54 | 84 | 57 | 5 | 130 | | | | | |
| 3:51 | 84 | 57 | 8 | 110 | | | | | |

TABLE D-9

METEOROLOGICAL DATA

AIRCRAFT C-210, C-182, C-172 TEST DATE 10-5-82

| | SURFACE | | | | UPPER AIR | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | WIND | | | | | WIND | |
| TIME | TEMP (°F) | HUMIDITY (%) | SPEED (KTS) | DIRECTION | HT. ABOVE GND (FT.) | TEMP (°F) | HUMIDITY (%) | SPEED (KTS) | DIRECTION |
| 6:53 | 63 | 87 | 0 | 0 | 0 | 61 | 97 | 2 | 360 |
| 7:05 | - | - | 6 | 010 | 282 | 63 | 78 | - | - |
| 7:53 | 63 | 90 | 4 | 310 | 535 | 63 | 75 | - | - |
| 8:53 | 66 | 84 | 0 | 0 | 820 | 65 | 90 | - | - |
| 9:53 | 70 | 76 | 3 | 340 | 909 | - | - | 7 | 140 |
| 10:53 | 74 | 71 | 3 | 340 | | | | | |

TABLE D-10

METEOROLOGICAL DATA

AIRCRAFT Merlin, Gulfstream 900, Duchess

TEST DATE 10-19-82

| | SURFACE | | | | UPPER AIR | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | WIND | | | | | WIND | |
| TIME | TEMP (°F) | HUMIDITY (%) | SPEED (KTS) | DIRECTION | HT. ABOVE GND (FT.) | TEMP (°F) | HUMIDITY (%) | SPEED (KTS) | DIRECTION |
| 7:54 | 49 | 86 | 4 | 190 | 0 | 37 | 85 | 3 | 250 |
| 8:53 | 55 | 74 | 6 | 170 | 1000 | 51 | 40 | 17 | 215 |
| 9:53 | 59 | 60 | 5 | 210 | 2000 | 48 | 41 | 22 | 205 |
| 10:51 | 63 | 46 | 9 | 170 | | | | | |
| 11:51 | 67 | 39 | 10 | 150 | | | | | |

TABLE D-11

METEOROLOGICAL DATA

AIRCRAFT Navajo 350, PA-21-181, Bonanza

TEST DATE 10-20-82

| SURFACE | | | | | UPPER AIR | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | WIND | | | | | WIND | |
| TIME | TEMP (°F) | HUMIDITY (%) | SPEED (KTS) | DIRECTION | HT. ABOVE GND (FT.) | TEMP (°F) | HUMIDITY (%) | SPEED (KTS) | DIRECTION |
| 7:55 | 57 | 93 | 7 | 130 | 0 | 49 | 98 | 7 | 170 |
| 8:52 | 62 | 93 | 8 | 160 | 230 | 54 | 96 | - | - |
| 9:51 | 67 | 84 | 12 | 190 | 423 | 56 | 96 | - | - |
| 10:50 | 67 | 75 | 9 | 170 | 946 | - | - | 21 | 194 |
| | | | | | 1208 | 54 | 90 | - | - |

TABLE D-12

METEOROLOGICAL DATA

AIRCRAFT C-425 Conquest-I

TEST DATE 10-26-82

| | SURFACE | | | | UPPER AIR | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | WIND | | | | | WIND | |
| TIME | TEMP (°F) | HUMIDITY (%) | SPEED (KTS) | DIRECTION | HT. ABOVE GND (FT.) | TEMP (°F) | HUMIDITY (%) | SPEED (KTS) | DIRECTION |
| 7:52 | 44 | 60 | 9 | 320 | 0 | 46 | 48 | 6 | 335 |
| 8:52 | 49 | 52 | 13 | 320 | 276 | 46 | 40 | - | - |
| 9:52 | 55 | 45 | 12 | 3[illegible]0 | 948 | - | - | 25 | 354 |
| 10:50 | 58 | 39 | 15 | 350 | 1241 | 47 | 30 | - | - |

# APPENDIX E

## CESSNA 210 SUPPLEMENTAL NOISE MEASUREMENTS

## Appendix E

### CESSNA 210 Supplemental Noise Measurements

Introduction - In order to obtain additional data on the relationship between level flyover and takeoff noise levels, additional noise measurements were conducted with a Cessna Model 210 at Dulles International Airport on June 28, 1983.

A specific objective was to obtain data on the effect of angle of attach on noise levels. The same Cessna 210, N6333C, that was used in FAA takeoff measurements during 1982, was flown to provide a direct comparison with the earlier measurements. (see Table 1.1 and Table 1.2).

The noise measurements were conducted over a two-position array separated by 492 feet under the flight path.

The noise measurement systems were identical to the systems used in the test of June 1982.

Following the noise measurement flights, the tachometer was removed from the airplane for calibration. It was determined that the tachometer readings are approximately 180 RPM less than the true RPM's and the data were corrected accordingly.

Summary - The following comments summarize analysis of the data for the Cessna Model 210:

a. takeoff noise level at maximum continuous power 85.6dBA max

b. change in noise level with helical tip Mach Number ($M_H$) over a $M_H$ range of 0.77 to 0.91; dBA = 98.7 + 226 log ($M_H$)

c. there was no statistically significant change in noise level with engine power over a power range of 68% to 98%

d. the noise level at 98% engine power varied linearly with airspeed from 84.4 dBA in level flight at 150 kts true airspeed to 85.6 dBA in climbing flight at 100 kts TAS, normalized to the reference altitude of 640 feet.

Test Operations

Thirty-one flights were conducted over the measurement sites on a magnetic heading of approximately 300°. Seven different takeoff power-airspeed combinations were flown and flight path intercepts were used on these flights. Seven different power RPM combinations were flown in level flight. All flights were targeted for an altitude of 640 feet AGL over the primary site. All but two flights were within 20% of the target altitude and the average of all of the flights was 23 feet above the target altitude.

Weather conditions during the test period were close to a standard acoustic day. The wind was less than 2 knots; the temperature 82°F to 84°F; and the relative humidity 75% to 80%.

Tachometer Calibration - Following the noise measurement flights, the tachometer was removed from the airplane and calibrated. It was determined that the tachometer readings are approximatel 180 RPM less than the actual RPM's over the test range.

Results - Corrected data for the 31 events are listed in the Table. The noise level data are corrected to a reference altitude of 640 feet using the expression 22 log (Altitude/640). The true airspeed listed for the level flyover is the true airspeed over the primary Site 1. Due to flight pattern constraints, the aircraft was accelerating over the sites during the level flyovers. Speeds over Site 2 were not recorded but are estimated to be on

the order of 10 knots faster for the level flyovers. Speed was stabilized for the takeoff tests.

Linear regressions of the data were calculated with the following results:

Takeoff using 98% power: dBA = 92.67 - 0.02399 (TAS in knots)

Takeoff using 87% power: dBA = 90.03 - 0.04481 (TAS in knots)

For the level flyover data:

$$dBA = 15.97 + 115.9\ M_H$$

$$dBA = 98.70 + 225.9 \log M_H$$

Quadratic regressions were evaluated and provided very similar correlations. There was no significant change in noise level with engine power over the range measured.

Using the linear regressions, the data was corrected to the reference takeoff conditions, resulting in:

Takeoff noise level at maximum continuous power 85.6 dBA max

TABLE E-1

TAKEOFF

| EVENT | RPM | % PWR | TRUE AIRSPEED KTS | $M_H$ | $L_{AM}$ (CORRECTED TO 640 ft) PRIMARY SITE 1 | SITE 2 |
|---|---|---|---|---|---|---|
| A1 | 2880 | 98% | 103 | .896 | 90.1 | 86.4 |
| A2 | 2880 | 98% | 103 | .896 | 90.2 | 89.4 |
| A3 | 2880 | 98% | 103 | .896 | 91.7 | 89.5 |
| A4 | 2880 | 98% | 103 | .896 | 92.6 | 88.4 |
| C5 | 2880 | 95% | 84 | .892 | 93.0 | 90.3 |
| C6 | 2880 | 98% | 82 | .891 | 90.8 | 90.3 |
| D7 | 2880 | 98% | 92 | .894 | 93.6 | 89.1 |
| D8 | 2880 | 98% | 92 | .894 | 91.9 | 89.1 |
| E9 | 2880 | 98% | 113 | .899 | 91.6 | 88.0 |
| E10 | 2880 | 98% | 113 | .899 | 91.2 | 88.4 |
| F11 | 2880 | 98% | 133 | .905 | 89.6 | 88.4 |
| F12 | 2880 | 98% | 133 | .905 | 88.2 | 89.3 |
| B13 | 2770 | 87% | 82 | .858 | 86.9 | 85.4 |
| B14 | 2770 | 87% | 82 | .858 | 87.0 | 84.8 |
| B15 | 2770 | 87% | 103 | .863 | 87.3 | 83.6 |
| B16 | 2770 | 87% | 103 | .863 | 87.5 | 85.2 |

TABLE E-2

LEVEL FLYOVER

| EVENT | RPM | % PWR | TRUE AIRSPEED KTS | $M_H$ | $L_{AM}$ (CORRECTED TO 640 ft) PRIMARY SITE 1 | SITE 2 |
|---|---|---|---|---|---|---|
| G17 | 2880 | 98% | 149 | .910 | 88.1 | 89.5 |
| G18 | 2880 | 98% | 149 | .910 | 90.2 | 88.0 |
| G19 | 2880 | 98% | 149 | .910 | 88.7 | 90.1 |
| G20 | 2880 | 98% | 149 | .910 | 89.0 | 89.7 |
| G21 | 2880 | 98% | 151 | .911 | 89.8 | 90.3 |
| G22 | 2880 | 98% | 154 | .912 | 88.7 | 89.4 |
| H23 | 2710 | 85% | 146 | .859 | 84.4 | 82.3 |
| H24 | 2710 | 85% | 146 | .859 | 84.7 | 81.9 |
| I25 | 2830 | 84% | 133 | .890 | 90.2 | 86.5 |
| I26 | 2830 | 84% | 135 | .891 | 88.5 | 88.0 |
| I27 | 2830 | 84% | 140 | .893 | 89.3 | 86.6 |
| K28 | 2420 | 62% | 131 | .768 | 74.0 | 73.4 |
| L29 | 2550 | 63% | 133 | .807 | 77.2 | 76.2 |
| M30 | 2670 | 64% | 131 | .842 | | 79.9 |
| N31 | 2770 | 63% | 123 | .869 | 87.1 | 84.6 |

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